INSTRUCTION MANUAL

FOR THE

FM STEREO MODULATOR

TYPE 219A

SERVICE ENGINEERING
FILE

BOONTON RADIO COMPANY

Green Pond Road Rockaway, New Jersey

U. S. A.

7.5C/CP/1-64

Printed in U.S.A.

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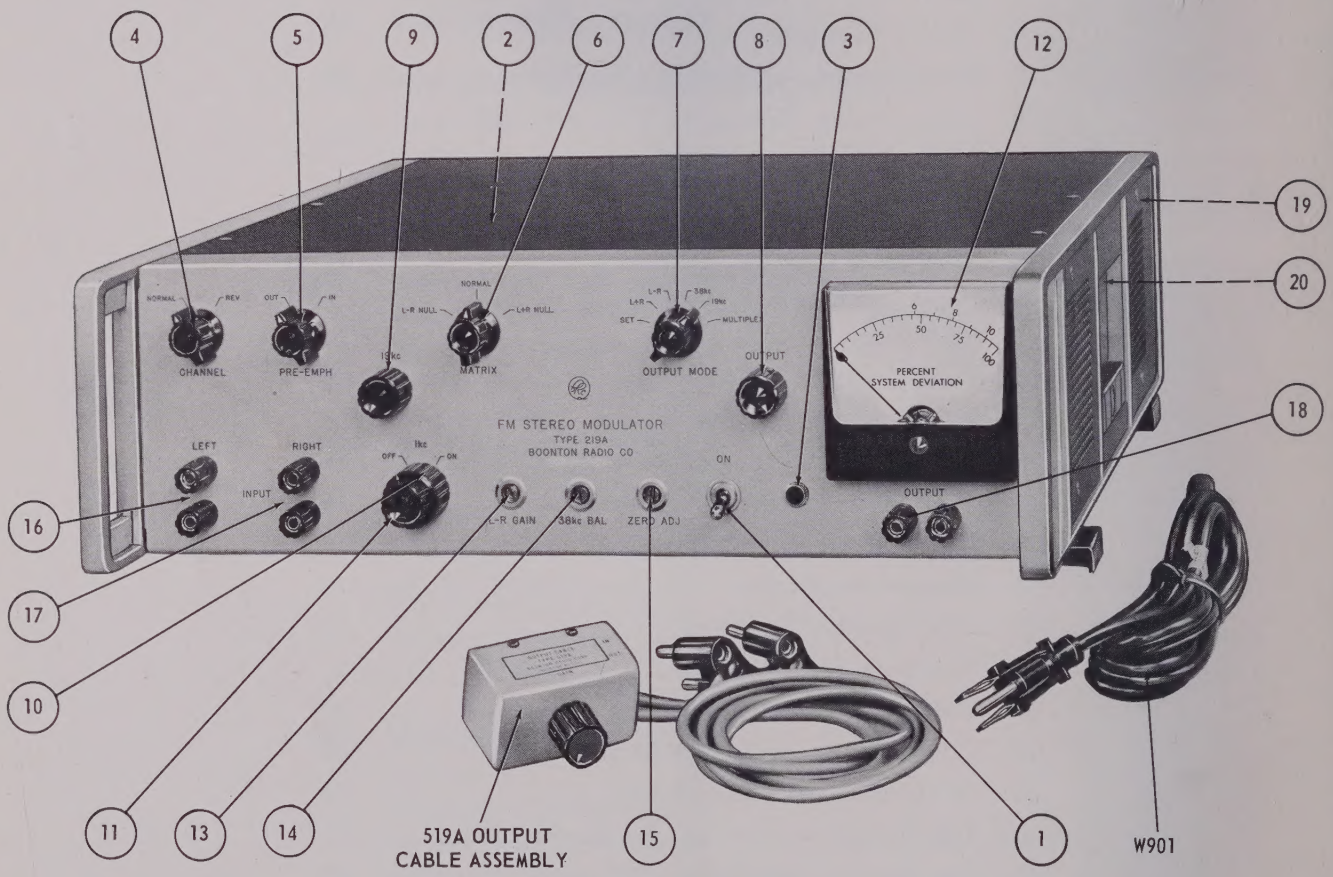


Figure 1. Panel Layout and Controls

SECTION I
DESCRIPTION

GENERAL

The FM Stereo Modulator Type 219A and a suitable FM Signal Generator; viz., BRC Type 202H, will provide the complete composite signal simulating the transmitted information of a commercial FM Stereo broadcast. With the internal audio oscillators in the 219A and the 202H, no other equipment is required. The output of the 219A may also be fed directly into the FM Stereo demodulator of an FM receiver.

A peak reading metering system, calibrated in "Percent System Deviation", is provided for setting and monitoring the levels of the individual subcarriers.

The FM Stereo Modulator is completely self-contained and is housed in a single cabinet which may be adapted for standard rack mounting.

PANEL LAYOUT AND CONTROLS

A front view of the instrument with all of its controls is shown in Fig. 1. All of the controls for operation of the 219A are located on the front panel. Instrument front panel designations (following item name) are shown below within quotation marks.

1. Power Switch "ON"

This switch applies power to the circuits when in the ON position.

2. Fuse

This fuse in the ac line is located on the back panel of the instrument (3 amp. for 115 v input, 1½ amp. for 230 v input).

3. Pilot Light

4. Channel Switch "CHANNEL"

The CHANNEL switch allows the electrical interchange of the RIGHT and LEFT channel inputs. When in the NORMAL position, the 1 kc internal oscillator is connected to the RIGHT channel only. When in the REV position the internal 1 kc oscillator is connected to the LEFT channel only. In either position of this switch, the RIGHT and LEFT terminals may be interconnected to put a 1 kc signal on both channels simultaneously.

5. Pre-emphasis Switch "PRE-EMPH"

The PRE-EMPH switch inserts or removes the 75 μsec pre-emphasis network in the RIGHT and LEFT channels simultaneously.

6. Matrix Switch "MATRIX"

The MATRIX switch permits checking the 219A for (L + R) and (L − R) null with the 1 kc internal oscillator.

7 Output Mode Switch "OUTPUT MODE"

The OUTPUT MODE switch performs the functions as outlined below:

SET — This position is for use when adjusting the level of deviation of a signal generator or FM Stereo demodulator.

L + R — This position allows the (L + R) and the SCA (if available) signals to be connected to the panel meter and the OUTPUT terminals (18).

L − R — This position allows the (L − R) and 19 kc pilot carrier signals to be connected to the panel meter and the OUTPUT terminals (18).

38 kc — This position removes all inputs to the balanced modulator and turns the 19 kc pilot off. The output of the balanced modulator is connected to the panel meter and this position can be used to null the 38 kc subcarrier.

19 kc — This position allows the 19 kc pilot carrier only to be connected to the panel meter and OUTPUT terminals (18) and is used to set the pilot carrier level.

MULTIPLEX — This position connects the complete multiplex signal, including SCA (if available), to the panel meter and the OUTPUT terminals (18).

8. Output Control "OUTPUT"

The OUTPUT control adjusts the voltage available at the OUTPUT terminals (18), independently of the meter readings.

9. 19 kc Control and Switch "19 kc"

The 19 kc control adjusts the level of the 19 kc pilot carrier. With the OUTPUT MODE switch (7) in the 19 kc position, the output is read as 6 to 10% of the total output. For higher levels than 10%, the OUTPUT MODE switch must be in the MULTIPLEX position with all other input signals turned off.

The push-pull, on-off switch allows turning the 19 kc pilot carrier off in any position of the 19 kc control by pushing the control knob in. When setting the (L + R) and (L − R) percent deviation, the 19 kc pilot carrier must be off.

10. 1 kc Switch "1 kc"

The 1 kc switch turns the internal 1 kc oscillator ON and OFF as indicated. Note that in the NORMAL position of the CHANNEL switch the internal oscillator is connected to the RIGHT INPUT terminal.

11. 1 kc Control "1 kc"

The 1 kc control, mounted coaxially with the 1 kc switch (10), sets the level of the 1 kc oscillator.

12. Panel Meter "PERCENT SYSTEM DEVIATION"

The panel meter monitors all signals available at the OUTPUT terminals (18). The range of the meter changes automatically depending on the position of the OUTPUT MODE switch (7).

The following controls are front panel screwdriver adjustments.

13. (L − R) Gain Control "L − R) GAIN"

The (L − R) Gain control is used to adjust the gain of the L − R channel for balancing with the (L + R) channel.

> **CAUTION:** When balancing (L − R) and (L + R) channels, the 19 kc pilot carrier should be off.

14. 38 kc Balance Control "38 kc BAL"

The 38 kc BAL control is the fine balance adjustment used to null or "balance out" the 38 kc subcarrier from the output of the 219A.

15. Meter Zero Adjustment Control "ZERO ADJ"

The ZERO ADJ control is used to set the *electrical* zero of the panel meter.

The following are the terminals and jacks of the 219A. All connections, with the exception of the SCA input and the 19 kc output, are located on the front panel of the instrument (See Fig. 1). The SCA input and the 19 kc output are mounted on the back panel of the instrument, directly in back of the panel meter.

16. Left Input Terminals "LEFT INPUT"

17. Right Input Terminals "RIGHT INPUT"

The LEFT and RIGHT INPUT terminals are used to introduce an external source (600-ohm source is recommended) of stereo information for the complete multiplex signal.

18. Output Terminals "OUTPUT"

The OUTPUT terminals make available for use all of the various outputs of the 219A.

19. 19 kc Output Jack "19 kc"

The 19 kc output jack, located on the back panel of the instrument, makes available, externally, a 19 kc pilot carrier at all times. This constant level (.3 volt minimum) output is for the purpose of oscilloscope synchronization only, as the low distortion output specified in Section II — Specifications is not available from this jack.

20. SCA Input Jack "SCA"

The SCA input jack, located on the back panel of the instrument, is used to introduce an external source of SCA (Subsidiary Communication Authorization) information to the multiplex signal of the 219A. This SCA signal should consist of a subcarrier in the 20 to 75 kc range which is, in turn, frequency modulated with an audio signal. It is recommended that the external source impedance be in the 600-ohm range for best results.

SECTION II
SPECIFICATIONS

Input Characteristics

LEFT (L) & RIGHT (R) INPUTS

FREQUENCY RANGE: 50 cps. to 15 Kc.
Level: 1.7 ±0.3 volts rms*.
*For 90% peak multiplex output with either a Left (L) or Right (R) input.
Impedance: 10 K ohms shunted with 30 pf.
Pre-emphasis: 75 μsec. pre-emphasis switchable in or out of circuit.

SUBSIDIARY COMMUNICATIONS (SCA) INPUT

FREQUENCY RANGE: 20-75 Kc.
Level: 1.0 volts rms*.
*For approx. 10% peak multiplex output.
Impedance: 10 K ohms.

Modulating Oscillator Characteristics

OSC FREQUENCY: 1 Kc.

OSC ACCURACY: ±10%.

OSC OUTPUT:
Switchable into either (L) or (R) input.

OSC DISTORTION: <1%.

Output Characteristics

LEVEL: 0-7.5 volts peak (multiplex output).

LOAD IMPEDANCE:
>1500 ohms shunted with <200 pf.

RESIDUAL HUM & NOISE:
>60db below 100% output.

CROSSTALK: >40db below 100% output.
*(L — R) into L + R).

METERING:
Range: 0-10%* (19 Kc. and 38 Kc. only).
0-100%*.
*Multiplex output; output adjustable 0-7.5 volts peak for 100% meter indication.
Calibration: 0-10% in increments of 1%, 6-10%, 0-100% in increments of 5%.
Accuracy: ±2% f.s.*.
*±1% relative accuracy at 45% for (L + R) and (L — R) and at 1/2 of 90% for multiplex signal.

MATRIX: Normal, L + R null, L — R null.

OUTPUT MODES: Switchable for L + R, L — R, 19 Kc. pilot carrier, 38 Kc. residual carrier or multiplex signal.

PILOT CARRIER: Frequency: 19 Kc.
Accuracy: ±0.01%.
Level: 0-30%*.
*Multiplex output.

MONAURAL (L + R): Output Level: 0-100%*.
*Multiplex output with either an L or R signal.
Fidelity: 50 cps. —15 Kc. ±1db*.
*±0.2db and ±1.5° relative to (L — R).
Distortion: <1%*.
*At 45% composite output.

DOUBLE SIDEBAND SUPPRESSED CARRIER (L-R)

FREQUENCY: 38 Kc.

FREQUENCY ACCURACY: ±0.01%.

CARRIER LEVEL: <0.5% (Composite output).

OUTPUT LEVEL: 0-100%*.
*Composite output with either an L or R signal.

FIDELITY: 50 cps. —15 Kc. ±1 db*.
*±0.2db and ±1.5° relative to (L + R).

DISTORTION: <1%*.
*At 45% composite output.

SUBSIDIARY COMMUNICATIONS (SCA)

OUTPUT LEVEL: 0-20% (Composite output).

FIDELITY: 20-75 Kc. ±0.5 db.

DISTORTION: <1.0%*.
*At 10% composite output.

OSCILLOSCOPE SYNCHRONIZING SIGNAL

FREQUENCY: 19 Kc.

OUTPUT LEVEL: 0.3 volts rms minimum.

IMPEDANCE: 25 ohms nominal.

Accessories

FURNISHED: None.

AVAILABLE: Type 202-H Signal Generator
Type 207-H Univerter
Type 519-A Output Cable.

Tube Complement

1 — 6AU8A	4 — 12AU7A	1 — 6X4
3 — 6DR7	2 — 12AT7	4 — 1N1764
3 — 7199	2 — Ballast	1 — 1N662
4 — 7543	1 — OG3	4 — 1N34A
		1 — 1N1763

Physical Characteristics

MOUNTING: Cabinet for bench use; readily adaptable for 19" rack mounting.

FINISH: Gray engraved panel, green cabinet. (Other finishes available on special order).

DIMENSIONS: See Fig. 2.

WEIGHT:
Net: 35 lbs. (15.8 kg)
Gross Domestic: 45 lbs. (20.3 kg)
Gross Export: 75 lbs. (34.8 kg)
Legal Export: 40 lbs. (18 kg)

Power Requirements

219-A: 105-125/210-250 volts, 50-60 cps, 150 watts.

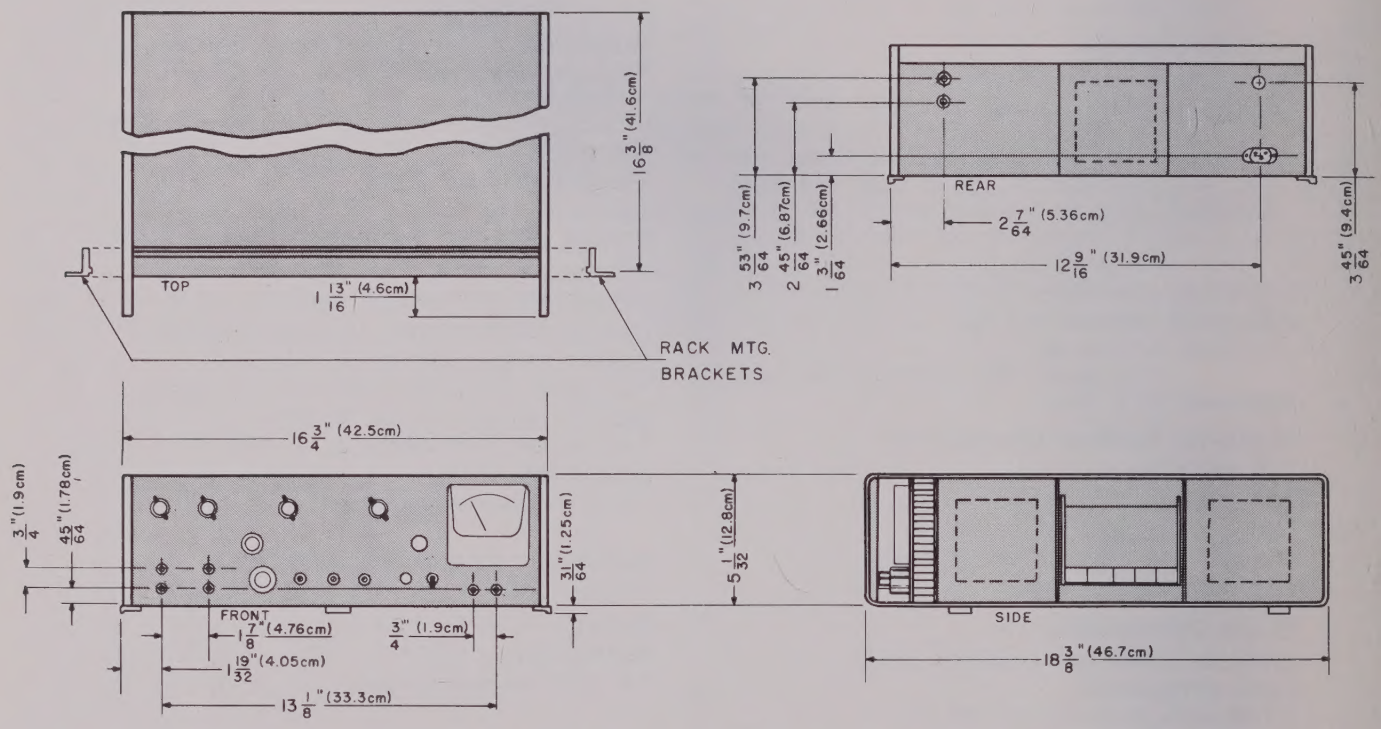


Figure 2. 219A Dimensions

SECTION III
OPERATING INSTRUCTIONS

INSTALLATION

Remove the Type 219A FM Stereo Modulator from its shipping carton and place it in position on a test bench. If the instrument is to be mounted in a rack, refer to Fig. 3 for mounting the accessory hardware.

Connect the power cord to the power socket at the rear of the 219A. Then connect the power cord to a 105-125 v, 50 or 60 cps source. An input voltage switch is on the chassis at the left rear of the instrument and may be operated to use the 219A with a 210-250 v, 50 or 60 cps source. (This switch is accessible only after removal of the top cover).

NOTE: Reverse voltage plate on back panel to agree with switch and change fuse as described under "2. Fuse".

Set the power switch to the ON position and allow unit to warm up a minimum of one hour before making any adjustments.

PRELIMINARY INSTRUCTIONS

Operating Precautions

COOLING FAN

Check to assure cooling fan is in operation. Movement of air from side vents will confirm operation.

PROPER LOADING ON 219A TERMINALS

Distortion will result from overloading the circuits. The input signal should not exceed 90% modulation, which is 45% modulation for each channel. When using a dynamic input signal (Pre-emphasis IN) with a wide range of frequencies, the input level should be adjusted using a 15 kc test signal. Also, to avoid phase or amplitude distortion, the minimum impedances for all externally connected equipment should be observed; i.e., 1500 ohms (minimum) with 200 pf capacitance (maximum) for the 219A output, 10K ohms (minimum)

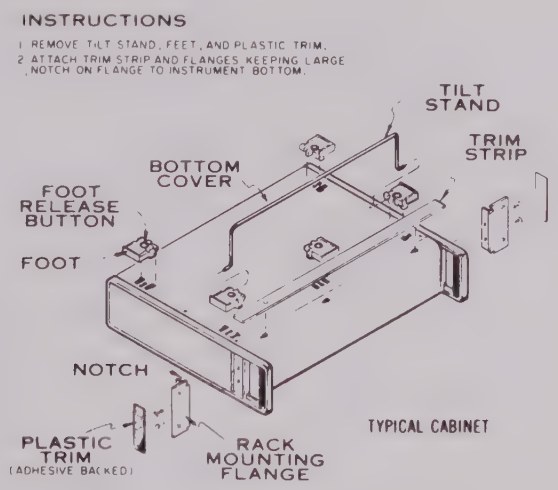


Figure 3. Rack Mounting Instructions

with 200 pf capacitance (maximum) for the 19 kc output, and 600 ohms nominal impedance for the SCA input. Avoid loading the RIGHT INPUT terminals with the 1 kc switch is in the "ON" position.

When testing circuits which need a low level and have highly reactive inputs, such as semiconductor multiplex decoders, an attenuator must be used. The 219A must be loaded with 1500 ohms. A 1.5v peak-to-peak requirement then would be a 10 to 1 attenuator, employing a 1.33K-ohm series resistor and a 150-ohm shunt resistor. (See Fig. 4.)

Since the operation and connection of the 219A is critical to its performance, every set-up should be thoroughly checked. Indiscriminate assumptions will lead to gross errors in results.

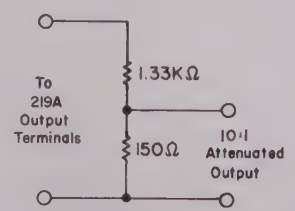


Figure 4. 10 to 1 Attenuator

OSCILLOSCOPE CONSIDERATIONS

It is possible that an oscilloscope might be used to set the relative gain of (L − R) to (L + R). For audio frequency inputs below 200 cps, most oscilloscopes must be operated direct coupled. The best of low frequency oscilloscopes contribute a noticeable phase shift error when ac coupled.

The overall frequency response should be within ±0.2 db from dc to 200 kc. A fallacy has arisen that the wider the frequency response, the better the oscilloscope is for observing multiplex patterns. This is not true. Many of the wide band oscilloscopes have peculiar amplitude and phase quirks in the 20 kc to 50 kc region due to gain crossover or compensating networks, etc. The most accurate method of checking this is to compare the oscilloscope indication to a laboratory standard thermal milliammeter, throughout the desired frequency range, using a low distortion test oscillator such as an -hp- 650A.

The most serious errors occur in

the use of incorrectly compensated oscilloscope probes and narrow bandwidth, sharp cut-off, vertical amplifiers.

HUM

When operating test instruments or line equipment which are sensitive to very low frequencies, power line "hum" may result from various sources. Before operating a set-up consisting of various pieces of equipment, check for hum. To reduce this annoyance as much as possible, follow these suggestions.

1. Connect all equipment to external power line ground at only one place. This might require the conversion of a three-wire power plug to a two-wire plug, using an adapter.
2. If possible, reverse the power plugs in the outlets for minimum hum in the overall system.
3. Assure good signal path grounds between the various pieces of equipment.

INSTRUMENT CHECKOUT

Front Panel Screwdriver Adjustments

The three front panel screwdriver adjustments have been preset at the factory and should normally not require adjustment during initial operation of the instrument. These adjustments are merely intended to provide compensation for tube aging, etc. Before the adjustments are checked, turn off the power and check the adjustment of the meter mechanical zero. The three controls are checked as follows:

(L — R) GAIN

1. Set the front panel controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	OUT
MATRIX	NORMAL
19 kc Switch	Off (pushed in)
OUTPUT MODE Switch	(L + R)
1 kc Switch	ON
1 kc Control	Adjust for 45% reading on panel meter.

2. Rotate the OUTPUT MODE switch to the (L — R) position. The panel meter should read 45%.

38 kc BAL

NOTE: (L — R) GAIN must be properly adjusted before adjusting this control.

1. Set the front panel controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	OUT
19 kc Switch	Off (pushed in)
OUTPUT MODE Switch	38 kc
1 kc Switch	ON
1 kc Control	Adjusted for 45% reading on panel meter (with OUTPUT MODE switch in (L + R) position).

2. The panel meter should read zero. This indicates a static balance of the 38 kc modulator.
3. Rotate the OUTPUT MODE switch to the MULTIPLEX position and note the output level on the panel meter.
4. Rotate the CHANNEL switch to the REV position. The output level should be identical to the level observed in step 3 if the 38 kc BAL adjustment is dynamically balanced. Touch up of the 38 kc BAL control may be required to achieve this balance.

ZERO ADJ

1. Set the front panel controls as follows:

Control	*Position*
CHANNEL	not significant
PRE-EMPH	not significant
19 kc Switch	Off (pushed in)
OUTPUT MODE Switch	19 kc
1 kc Switch	OFF

2. The panel meter should read zero.

Front Panel Controls

19 kc CONTROL

1. Set the front panel controls as follows:

Control	*Position*
CHANNEL	not significant
PRE-EMPH	not significant
OUTPUT MODE Switch	19 kc
1 kc Switch	OFF

2. With the 19 kc switch in the on position (pulled out), rotate the control to assure a meter reading up to 10%.
3. Change the OUTPUT MODE switch to the MULTIPLEX position.
4. Turn the 19 kc control to the full clockwise position. The panel meter should read in excess of 30%.

MATRIX SWITCH

1. Set the front panel controls as follows:

Control	*Position*
CHANNEL	not significant
PRE-EMPH	OUT
MATRIX	NORMAL
OUTPUT MODE Switch	(L + R)
1 kc Switch	ON
1 kc Control	Adjust for 45% reading on the panel meter.

2. Change the OUTPUT MODE switch to the (L — R) position. The panel meter should read 45%.
3. With the OUTPUT MODE switch in the (L — R) position, set the MATRIX switch to (L — R) NULL. The panel meter should read 0%.
4. Change the OUTPUT MODE switch to the (L + R) position. The panel meter should read approximately 90%.
5. With the OUTPUT MODE switch in the (L + R) position, change the MATRIX switch to the (L + R) NULL position. The panel meter should read 0%.
6. With the OUTPUT MODE switch in the (L + R) position, change the MATRIX switch to (L — R) NULL. The panel meter should read approximately 90%.

NOTE: Using the procedure given above, all of the front panel controls may be checked for proper operation except the PRE-EMPH switch and the OUTPUT control. These two controls require additional equipment for checkout and must be checked in accordance with the procedure given below.

PRE-EMPH SWITCH

1. Set the front panel controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	IN
19 kc	Off (pushed in)
OUTPUT MODE Switch	MULTIPLEX
1 kc Switch	OFF

2. Connect an external audio oscillator to the LEFT or RIGHT INPUT terminals. Apply a 15 kc input signal and adjust the external audio oscillator to read 100% on the panel meter.

3. Rotate the PRE-EMPH switch to the OUT position. The panel meter should read approximately 24% (or −12 db).

OUTPUT CONTROL

1. Set the front panel controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	not significant
19 kc	Off (pushed in)
OUTPUT MODE Switch	SET
1 kc Switch	not significant
1 kc Control	Adjust for 100% reading on panel meter.

2. Connect an ac VTVM to the OUTPUT terminals. (These terminals should be loaded with a 1500-ohm resistor.)

3. When the OUTPUT control is rotated from minimum to maximum, the ac VTVM should read from 0 to approximately 5.3 v rms.

USING THE FM STEREO MODULATOR

The FM Stereo Modulator may be fed directly into an FM Stereo demodulator (See Operating Precautions for proper output load). The Operating Chart indicates the types of signals available from the 219A for testing purposes. External oscillators and/or generators may be connected into the RIGHT and LEFT INPUT terminals to obtain any desired signal to the demodulator. An ac VTVM or calibrated oscilloscope should be used across the OUTPUT terminals to monitor the demodulator input to avoid overloading.

The 219A may also be operated in conjunction with an FM generator. When used with a BRC Type 202H FM-AM Signal Generator and a BRC Type 519A Output Cable Assembly, it becomes the heart of a complete FM Stereo system. The block diagram of Fig. 5 shows all the major components with the interconnecting cables of such a system. With this system, all tests on an FM Stereo receiver are possible, whether for measurement or alignment purposes. The 202H has eight fixed frequencies, from 50 cps to 25 kc, for a variety of audio test signals which are continuously variable by means of the 519A GAIN control.

An FM Stereo system, using the 219A, 202H, and 519A (Fig. 6), is set up as follows:

1. Set the 219A front panel controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	OUT
MATRIX	NORMAL
19 kc	Off (pushed in)
OUTPUT MODE Switch	SET
1 kc Switch	OFF
1 kc Control	Adjust for 100% reading on panel meter.
OUTPUT Control	Full clockwise

2. Set the 202H Signal Generator front panel controls as follows:

Control	*Position*
Mod Meter Switch	FM
Dev KC Switch	75 or 250
Mod Control (FM)	Mid-position
Mod Control (AM)	Maximum counterclockwise
Freq CPS	Desired modulating frequency
Int Mod	Off

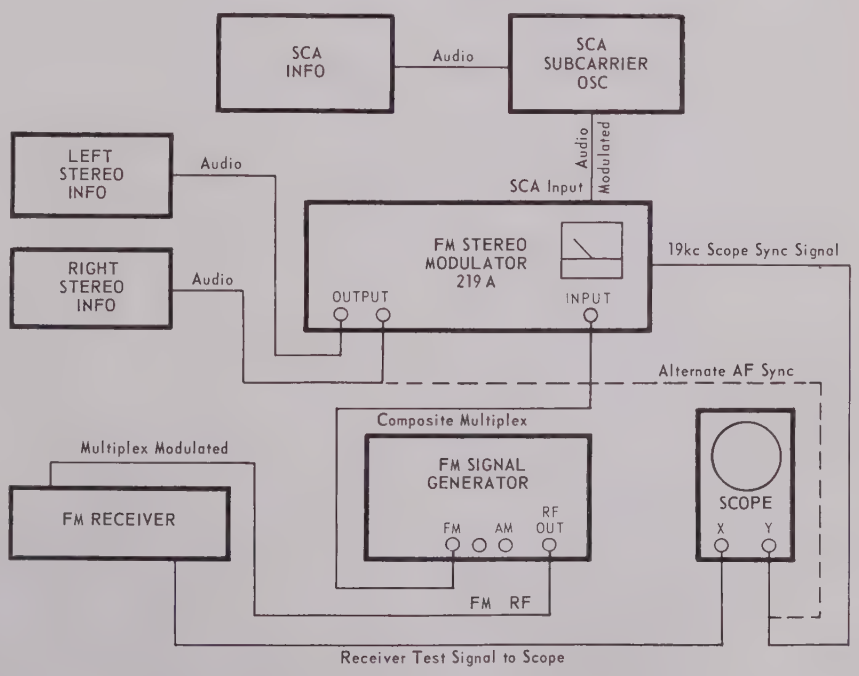


Figure 5. Block Diagram — FM Stereo Test System

3. Adjust the Mod Control (FM) control on the 202H for 75 kc deviation on the 202H Modulation Meter.

NOTE: In this procedure, the 219A panel meter at 100% is correlated with the 202H Modulation Meter at 75 kc deviation with a 1 kc sine wave.

4. Change the OUTPUT MODE switch on the 219A to the (L + R) position.

5. Change the Int Mod control on the 202H to the AM position.

6. Adjust the GAIN control on the 519A for a 45% reading on the 219A panel meter.

7. Change the OUTPUT MODE switch to the (L − R) position. The 219A panel meter should read 45%.

8. Change the 219A front panel controls as follows:

Control	*Position*
OUTPUT MODE	19 kc
19 kc Switch	On (pulled out)
19 kc Control	Adjust for 9% reading on panel meter.

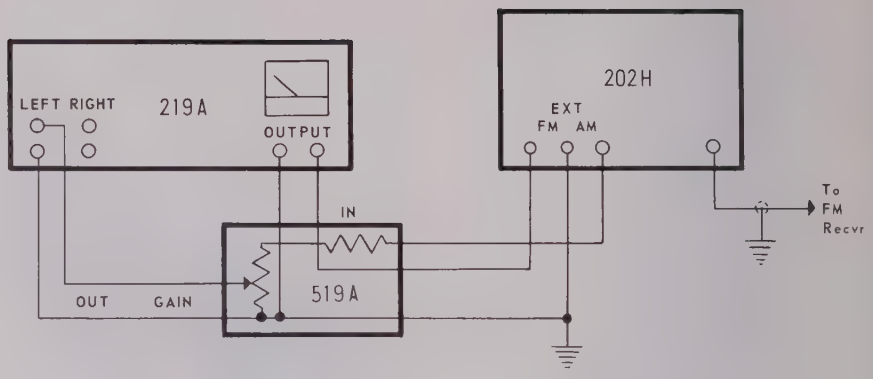


Figure 6. Interconnection Diagram — 219A and 202H Signal Generator

NOTE: The 19 kc pilot carrier can be adjusted from 0 to 10% of system deviation with the OUTPUT MODE switch in the 19 kc position. For higher percentage of pilot carrier, the modulation signal can be turned off and the pilot carrier can be adjusted with the OUTPUT MODE switch in the MULTIPLEX position.

9. Change the OUTPUT MODE switch to the MULTIPLEX position.

At this point, the FM Stereo modulating signal is modulating the RF carrier in the 202H. The RF controls on the 202H may be adjusted as required. It should be noted that the 202H Modulation Meter is an average reading meter indicating FM deviation. Since the output of the 219A is a complex signal, the meter indication on the 202H Modulation Meter is not significant. The 219A panel meter is a peak reading meter indicating percent system deviation and will be correct.

Type of Output Signal Required	Signal Input RIGHT	Signal Input LEFT	Switch Positions CHANNEL	Switch Positions PRE-EMPH	Switch Positions OUT MODE	Switch Positions 1 kc	Controls 1 kc	Controls 19 kc	Meter Readings[2] (L + R)	Meter Readings[2] (L − R)	Meter Readings[2] 19 kc	Remarks
Complete Multiplex[1] Signal on L and R External Signal	Ext.	Ext.	NORMAL	IN (optional)	MULTI-PLEX	OFF	—	Oper-ating	45%	45%	10%	
Complete Multiplex[1] Signal on R Only External Signal	Ext.	None	NORMAL	IN (optional)	MULTI-PLEX	OFF	—	Oper-ating	45%	45%	10%	
Complete Multiplex[1] Signal on R Only Internal Signal	None	None	NORMAL	OUT	MULTI-PLEX	ON	Oper-ating	Oper-ating	45%	45%	10%	
Complete Multiplex[1] Signal on L Only External Signal	None	Ext.	NORMAL	IN (optional)	MULTI-PLEX	OFF	—	Oper-ating	45%	45%	10%	
Complete Multiplex[1] Signal on L Only Internal Signal	None	None	REV.	OUT	MULTI-PLEX	ON	Oper-ating	Oper-ating	45%	45%	10%	
(L + R) Only[1] Signal on L and R External Signal	Ext.	Ext.	NORMAL	IN (optional)	(L + R)	OFF	—	—	100%	—	—	Equivalent to Monaural Signal
(L + R) Only[1] Signal on L and R Internal Signal	External Jumper		—	OUT	MULTI-PLEX	ON	Oper-ating	Oper-ating	90%	—	10%	Monaural Signal Plus 19 kc Pilot
(L + R) Only[1] Signal on L and R Internal Signal	External Jumper		—	OUT	(L + R)	ON	Oper-ating	—	100%	—	—	Equivalent to Monaural Signal
(L − R) Only Signal on L and R External Signal	Ext.	Ext.	—	IN (optional)	(L − R)	OFF	—	Oper-ating	—	—	10%	Meter Reading Depends on Type Of Input
(L − R) Only Signal on L and R Internal Signal	External Jumper		NORMAL	OUT	(L − R)	ON	Oper-ating	OFF	—	0%	—	Used to Check 38 kc Bal
19 kc Signal Only	—	—	—	—	19 kc or MULTI-PLEX	OFF	—	Oper-ating	—	—	Variable 0-10% 0-30%	See Note #3 See Note #4
SCA Signal Only	Signal to SCA Input Jack				MULTI-PLEX or (L + R)	OFF	—	—	—	—	—	

1. *SCA Signal Optional*
2. *Based on 100% which is 75 kc deviaton*
3. *Due to automatic meter range switching, the 19 kc carrier level must be read in MULTIPLEX position for over 10% deviation. In this case there should be no input signals present.*
4. *A .3v rms nominal 19 kc sync signal is available from 19 kc output jack.*

OPERATING CHART

SECTION IV
THEORY OF OPERATION

GENERAL

The FCC approved system for the broadcasting of FM Stereo (FCC Docket 13506 — (April 20, 1961) was designed to provide good stereo reproduction and all SCA (Subsidiary Communications Authorization) broadcasting, without obsoleting existing consumer FM receiving equipment. FM Stereo broadcasting is accomplished by the simultaneous modulation of a single carrier with three basic pieces of information: the monaural portion, the stereo information portion, and the 19 kc pilot carrier. The baseband spectrum, consisting of these three parts, is shown in Fig. 7. The SCA is shown in the spectrum at 67 kc ± 6700 cps.

The monaural signal, or (L + R), is the sum total of all the right and left channel information. A monaural receiver will pick up and demodulate this signal in the normal way. The stereo information signal (L − R) is the result of the right channel information subtracted electronically from the left channel information and the resultant used to modulate a 38 kc double sideband, suppressed carrier (DSSC) system. The 19 kc pilot carrier, which is the first subharmonic of the 38 kc subcarrier, is related to the subcarrier, not only in frequency, but also in phase. In the FM stereo receiver, this pilot carrier is used to establish the frequency and phase of the 38 kc subcarrier when it is reinserted to demodulate the (L − R) information from the DSSC system.

THE STEREO MODULATOR

The 219A is designed to produce the composite FM Stereo signal using internal or external modulating facilities. The output of this modulator is suitable for use directly into an FM Stereo Demodulator or with an RF generator into the antenna of an FM Stereo receiver.

The 219A consists of many distinctly separate sections of low frequency circuitry, linked together as indicated by the block diagram shown in Fig. 8. However, the formation of the FM Stereo composite signal described above can be readily seen.

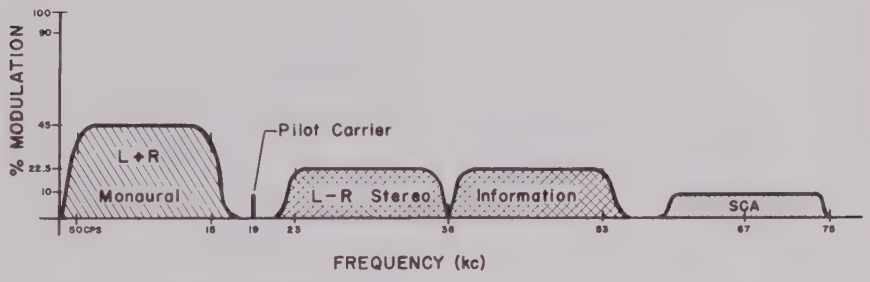


Figure 7. Idealized Baseband Spectrum for FM Stereo System and SCA

The monaural (L + R) portion is formed by electronic addition in the (L + R) adder amplifier (V201), where the left channel information is impressed on one grid of a dual triode and the right channel information on the other grid. With a common plate load, the signals are added. The (L + R) signal is passed through a low pass filter and on to another added amplifier to be incorporated in the composite FM Stereo Signal available at the output.

The stereo information (L − R) portion is formed in an amplifier V202. In this case the left and right channel information is connected to the grids of a triode-pentode. The circuit configuration of this stage is such as to cause a phase reversal of one input and the resultant output becomes the difference signal between the two input signals. (In the case of equal left and right channel information, the output of this stage is zero.) An (L − R) signal is used to modulate the carrier of the double sideband suppressed carrier system (to be described later). As with the (L + R) signal, the (L − R) signal is passed through a filter. The (L − R) filter is a bandpass filter with 3 db points at 20 kc and 67 kc [See Maintenance (L − R) Bandpass Fig. 21 for typical curve.] It passes into the output adder amplifier V401B to become a part of the composite FM Stereo signal.

The 19 kc pilot carrier is generated by the 19 kc crystal oscillator (V802). The low distortion sine wave output is passed through two cathode followers and added to the composite FM Stereo system in the output amplifier.

To provide a relatively low impedance output (75 ohms), the composite FM Stereo signal is connected to the output terminals via a cathode follower.

SPECIAL CIRCUIT DETAILS

With a few exceptions, the circuitry used in the 219A is basic. The special circuits requiring explanation will be discussed in the following.

Double Sideband Suppressed Carrier Modulator

The double sideband suppressed carrier modulator transmits the (L − R) signal. The circuit used is shown in block diagram form in Fig. 9. It uses four vacuum tubes biased to maximize the second order coefficient in the power series, representing the plate current as a function of grid-cathode voltage. In this circuit a balance of the 38 kc carrier is achieved which is more than 80 db below the fundamental components of plate current. In addition, excellent balance of the baseband audio signals from 50 cps to 15,000 cps is

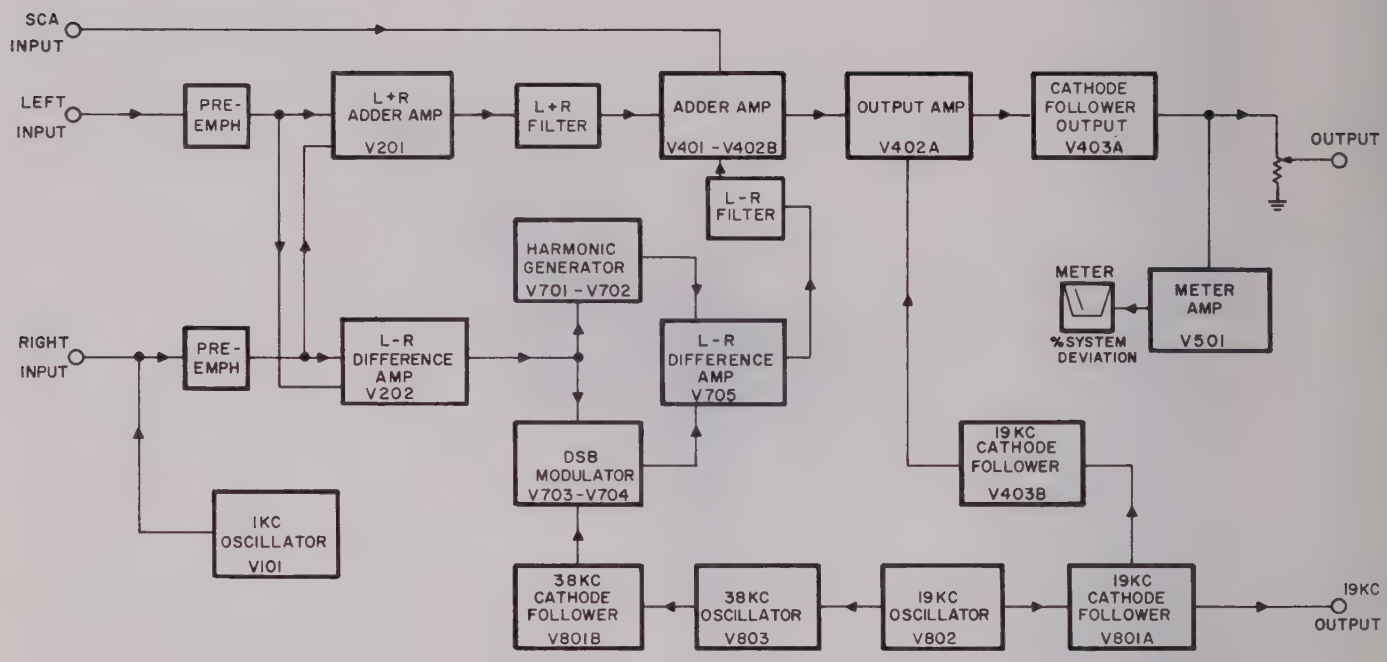


Figure 8. 219A Block Diagram

achieved. As the modulator generates the desired sidebands by means of the second order coefficient, large amounts of second harmonic of both the baseband and the carrier are generated. The subcarrier second harmonic at 76 kc is far enough removed from the desired output spectrum to be easily filtered out. However, the second harmonic of the baseband above 11.5 kc falls within the desired output spectrum of the modulator and therefore is not filterable. The second pair of tubes, shown in Fig. 9, corrects this problem by generating a second harmonic of the baseband. This second harmonic is combined with the basic modulator output by means of the difference amplifier shown in the diagram, to produce a bucking baseband second harmonic output. The combined output baseband second harmonic is considerably more than 40 db below the desired sideband at 90% modulation.

This modulator has an extremely stable circuit. The baseband and carrier signals are supplied at low level and very low impedance, thus minimizing interaction and providing for extremely flat frequency and phase response, since no transformers need be involved in the broad-band circuits.

19 kc and 38 kc Oscillators

The 19 kc oscillator (Fig. 10) is a regenerative, tuned amplifier with a quartz crystal controlling the feedback. The cathode is connected to a constant current source to provide dc stability for the oscillator. Part of the 19 kc output is utilized by a cathode follower (V802B) to provide bias for the oscillator, contributing to 19 kc oscillator amplitude stability. The output of V802B is connected to a full-wave rectifier consisting of a transformer (T801) and two diodes (CR801 and CR802).

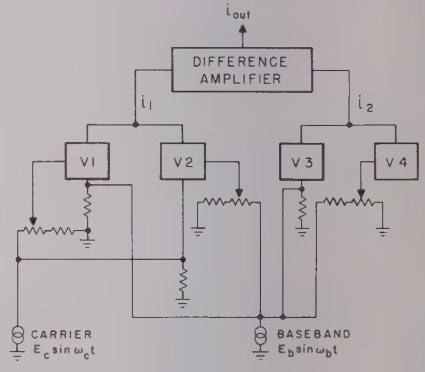
The 38 kc pulses from the rectifiers are used to synchronize the 38 kc phase locked oscillator V803. The 38 kc oscillator is transformer coupled to the modulator.

The Percent System Dev. Meter

This meter is a peak reading device. The meter detector is connected directly to the cathode of the output tube (V403A) which is a low source impedance. By use of a relatively large discharge resistor of 8.2 megohms with the low source impedance, the meter response is such as to follow complex waveshapes as easily as sine waves.

The Power Supply

The power supply utilizes conventional circuitry and supplies four different outputs for operation of the



i_1 contains the following terms:

$\frac{C_2 E_c E_b}{} [\cos (\omega_c - \omega_b) t - \cos (\omega_c + \omega_b) t]$ desired output

$\frac{C_2 E_c^2}{2} \sin 2\omega_c t$ undesired carrier second harmonic

$\frac{C_2 E_b^2}{2} \sin 2 \omega_b t$ undesired baseband second harmonic

i_2 contains only $\frac{C_2 E_b^2}{2} \sin 2 \omega_b t$

$i_{out} = i_1 - i_2$, thus cancelling undesired baseband second harmonic

Figure 9.
Double Sideband Suppressed Carrier Modulator — Block Diagram

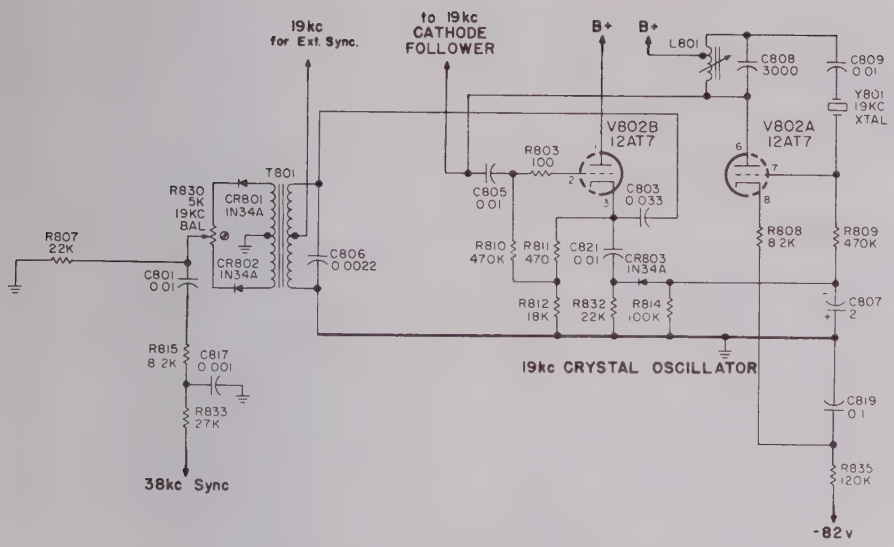


Figure 10. 19 kc Crystal Oscillator

FM Stereo Modulator. Their outputs are as follows:

1. 210 vdc at 100 ma regulated supply.
2. −82 vdc at 7 ma — zener diode regulated.
3. 6.3 vac ballast tube regulated filament supply[1].
4. 6.3 vac unregulated filament supply[1].

[1] Filament supplies are floating with respect to chassis ground, maintaining approximately 15 vdc on all filaments to reduce heater-cathode hum effects.

SECTION V
APPLICATIONS

GENERAL

This section is devoted to a discussion of specific applications of the 219A FM Stereo Modulator as applied to FM Stereo receiving equipment.

This modulator is so designed as to be usable by itself to produce the basic FM Stereo signals such as would be used to modulate a commercial FM transmitter. With a signal generator, it is capable of producing the same type of signal as that transmitted by an FM station. For design and testing an FM Stereo receiver, both the base-band FM Stereo signal and the modulated RF carrier are required.

Fig. 11 shows in block diagram form a basic FM Stereo receiving system. In the design of such a system, it is important that the frequency response of stages preceding the multiplex detector be adequate so as not to distort the multiplex signal in either phase or amplitude. Thus, initial testing of an FM Stereo system will require testing for adequate bandpass of input and IF amplifiers and also flatness of frequency response over the bandpass range. Irregularities in frequency response in the (L − R) range of 23 kc to 53 kc can cause loss of identity of the right and left channels. Poor response in the vicinity of 19 kc can affect the 19 kc pilot amplitude and phase to the multiplex detector, resulting in lack of stereo separation. It is also important to be able to check an FM receiver with a complete multiplex signal modulated on an RF carrier. This can be readily accomplished as described under Section III — Using the FM Stereo Modulator.

When performing base-band measurements, the 219A output is fed directly into the multiplex demodulator or adapter. Fig. 12 is a block diagram of a typical multiplex demodulator or adapter. This adapter must perform the following functions.

1. Must accept base-band output from the FM receiver and transfer a monaural signal (L + R) to the output of the adapter without phase shift or distortion.
2. Must be able to separate the 19 kc pilot carrier from the composite multiplex signal preserving both frequency and phase relationships.
3. Must be capable of generating a 38 kc signal of proper phase to reinsert the carrier in the double sideband suppressed carrier portion (L − R) of the complex multiplex signal.
4. In certain adapter designs the level of the 19 kc pilot carrier must control the 38 kc subcarrier oscillator.
5. Must be capable of matrixing the (L + R) with (L − R) information to produce the original left and right channels with low distortion and minimum phase shift.

The 219A FM Stereo Modulator can provide all of the signals required for designing or testing these functions.

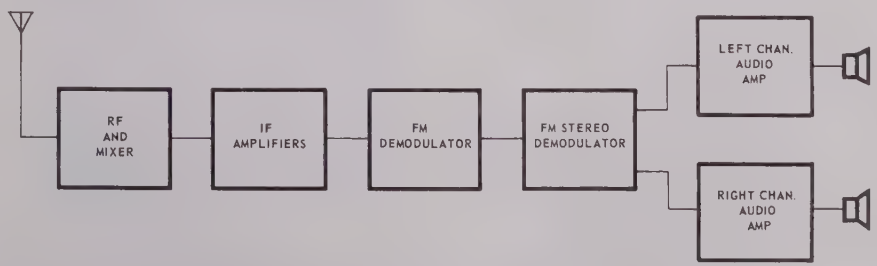


Figure 11. Basic FM Stereo Receiving System — Block Diagram

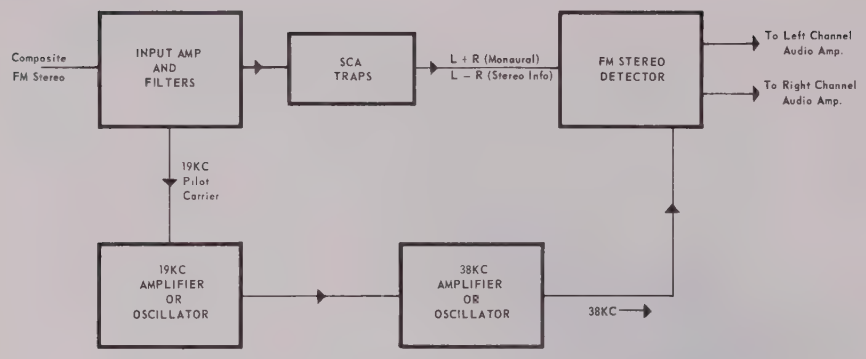


Figure 12. Basic FM Stereo Demodulator — Block Diagram

MONAURAL TESTING

To obtain a monaural signal (L + R)[1], the RIGHT and LEFT inputs of the 219A can be directly connected together (OUTPUT MODE switch — MULTIPLEX). When L = R in amplitude and phase, then L − R = O and there will be no signal from the (L − R) channel. This monaural signal may be checked at the demodulator output of the adapter (either RIGHT or LEFT channel) with a distortion analyzer, or referenced back to the input with an oscilloscope to determine phase shift over the monaural range of 50 cps to 15 kc.

19 kc PILOT

The 19 kc pilot carrier is available singly from the 219A without (L+R) and (L−R). The level is continuously variable, making all necessary measurements possible.

Varying the 19 kc carrier output can determine the minimum level required for locking the 38 kc oscillator in the adapter. Using the 19 kc pilot carrier with the composite multiplex signal, the filtering of the 19 kc pilot may be measured.

The phase relation between the 19 kc pilot carrier and 38 kc output of the demodulator oscillator can be determined by the oscilloscope method.

(L — R) CHANNEL

To obtain an (L − R) signal only, the OUTPUT MODE switch can be rotated to the (L − R) position. The internal (1 kc) or an external oscillator may be used to supply the input signal to the 219A. The 19 kc pilot carrier for operating the multiplex demodulator is available at this time at the output terminals.

A second method of obtaining an (L − R) signal only is to apply a single frequency to the 219A RIGHT and LEFT inputs such that the signal at one input is 180° out of phase with the signal at the other input (OUTPUT MODE Switch — MULTIPLEX). In this case L = (−R) so that L + (−R) = O eliminating the monaural portion of the complete multiplex signal. This signal would appear on an oscilloscope as shown in Fig. 13 if a 1 kc input signal were used. The output of the multiplex demodulator under these conditions is a RIGHT and LEFT channel of equal amplitude, but shifted in phase by 180°. The distortion of either channel and the phase shift between the two channels may be measured at this point.

Measurement of the (L − R) channel would cover the frequencies from 23 kc to 53 kc (38 kc ± 15 kc).

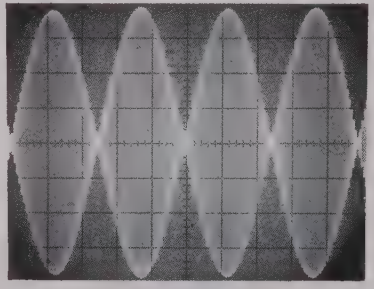


Figure 13.
(L — R) Signal from 219A Output

[1] For over 50% modulation, a signal requirement of less than 50% may be obtained directly by use of the (L + R) position of the OUTPUT MODE switch. In the (L + R) position of the OUTPUT MODE switch the 19 kc pilot is not available.

CHANNEL SEPARATION

The function of a multiplex demodulator is to separate the LEFT and RIGHT channels. This separation may be directly measured by first connecting an input signal to one channel only (RIGHT or LEFT) and measuring the output ratio of the LEFT and RIGHT channels. This measurement may be accomplished most accurately by the use of an instrument such as a wave analyzer, as the output of the adapter from the unused channel could contain 19 kc, 38 kc, hum, etc.

Regarding separation, it is of some significance that to achieve 30 db of separation the total phase shift contributed by the multiplex demodulator with its tuner cannot exceed ± 3° between the (L + R) and (L − R) channels at all modulating frequencies. The amplitude response to maintain this separation cannot vary more than ± .3 db between channels.

CHANNEL IDENTIFICATION

During the process of alignment of a multiplex demodulator it is sometimes possible that LEFT and RIGHT channels may become interchanged. Thus, with a signal injected in the RIGHT channel of the 219A FM Stereo Modulator, the signal output of the FM Stereo demodulator would appear out of the LEFT channel. To assure positive identification of the 219A output, a test can be made as follows:

1. Connect the vertical input of an oscilloscope to the 219A OUTPUT terminals.
2. Connect a phase shift network (Fig. 14) between the 19 kc output jack and the horizontal input to the oscilloscope.
3. With a LEFT input only, and the phase shift network adjusted for 45° (lagging), the oscilloscope pattern will appear as shown in Fig. 15A. Changing only the input to the RIGHT channel, the oscilloscope pattern will appear as shown in Fig. 15B.

SCA

SCA (Subsidiary Communications Authorization) signals may also be used with FM Stereo multiplex to transmit additional information chan-

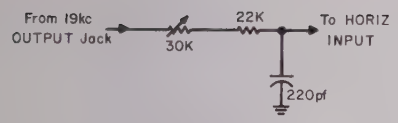
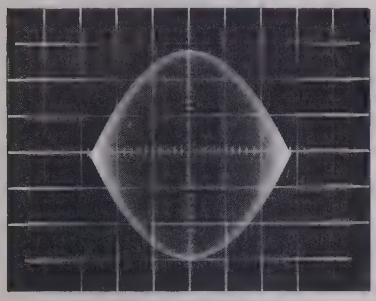
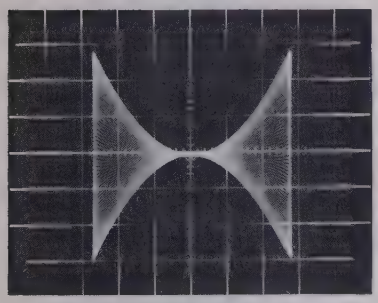


Figure 14.
Lagging Phase Shift Network

nels. The intelligence is FM modulated on subcarriers in the 53-75 kc range and is applied to the RF carrier along with the composite multiplex signal. An input jack on the rear of the 219A is provided for introducing such an SCA signal which is combined in the 219A and then appears on the OUTPUT terminals. The performance of multiplex demodulators may then be measured in the presence of SCA to determine that adequate steps have been taken to eliminate this undesired signal from the desired multiplex output.



(A)
Waveform Identifying
Left Channel



(B)
Waveform Identifying
Right Channel

Figure 15. Channel Identification

SECTION VI
MAINTENANCE

GENERAL

The 219A is a complex and compact instrument. The layout is such that most parts are easily accessible for maintenance and repair in the field. All parts are available after removal of the top and bottom covers. By use of the various switches and controls in conjunction with the built-in audio oscillator and meter, many of the circuits can be checked without external test equipment. The 219A does not generate an RF signal nor is an RF signal fed into it. Most of the circuitry involves the audio frequency range and the spectrum above it up to 125 kc maximum. This frequency range should be kept in mind when choosing the type of equipment used in the servicing of the 219A.

PREVENTATIVE MAINTENANCE

Ventilation and Filter Replacement

The 219A MUST ALWAYS be used with the blower in operation. The blower moves air from the rear of the instrument, through a filter mounted on the back panel, into the top and bottom compartments and out through the side vents. For efficient cooling operation, the filter should be periodically checked and cleaned. Under clean laboratory conditions this check should be made after 200 hours of operation. To clean the filter, the two captivated screws are loosened and the whole filter assembly is removed from the instrument. The filter unit is washed in water and any mild detergent. When dry, the assembly is replaced on the instrument.

To replace the filter element, the filter assembly must be removed from the back panel of the instrument. The filter element (BRC No. 308637) is inserted and the filter assembly reassembled to the back panel of the 219A.

Lubrication

The 219A requires no lubrication. The only mechanical moving part is the blower and the blower motor has sealed bearings that cannot be lubricated.

Special Precautions

To avoid overload damage to components in the 219A, DO NOT remove the following tubes unless the power to the instrument has been shut off: V701, V702, V703, V704, and V803.

TROUBLE SHOOTING AND REPAIR

Tube Replacement Guide (Page 18)

The Tube Replacement Guide is primarily a checklist to show the tube functions with the readjustments required after tube replacement. The "Symptoms Noted" information is included as an organized starting point in the event that the instrument is not performing properly.

To gain access to all tubes, the top cover only will have to be removed. See Fig. 16 for tube location diagram.

Voltage and Resistance Chart (Page 41)

The Voltage and Resistance Chart indicates normal operating conditions for the 219A with no external equipment attached. Voltages were checked with a VTVM (-hp-410B). Resistance readings were made under the same conditions with the power disconnected. Some resistance readings have been omitted as the readings have no significance; i.e., cases where electrolytic capacitors or semiconductor devices are connected in the circuit.

Waveforms Chart

The Waveforms Chart (Fig. 17) shows typical oscilloscope waveforms at various points or terminals, available either inside or outside of the 219A cabinet. The control settings and location of the oscilloscope input is shown for each waveform. The waveforms shown are not only useful for maintenance, but also during normal operation to assist in setting up the 219A.

Reference Symbol	Tube Type	Application	Adjustment Check Required	Symptoms Noted
V101	6AU8A	1 kc Oscillator	R104 and R111 1 kc Control	Weak, distorted, or no internal 1 kc signal.
V201	12AU7A	(L + R) Adder Amp.	R209 and C205	Weak, distorted, or no baseband. (L + R) gain varies depending on input channel.
V202	7199	(L − R) Diff. Amp.	R222 L − R GAIN Control	Weak, distorted or no stereophonic information. (L − R) gain varies depending on input channel.
V401	12AU7A	(L + R) Amp. (V401A)	None	Weak, distorted, or no baseband.
		(L − R) Amp. (V401B)	None	Weak, distorted, or no stereophonic information.
V402	7199	Output Amp. (V402A)	None	Weak, distorted, or no output.
		SCA Amp. (V402B)	None	Weak, distorted, or no SCA output.
V403	6DR7	Cath. Fol. Output (V403A)	OUTPUT Control	Weak, distorted or no output.
		19 kc Cath. Fol. (V403B)		Weak, distorted, or no 19 kc output.
V501	12AU7A	Meter Amp.	R510, R512, R514	Weak or no meter indication. Full up or down scale deflection.
V701 V702	7543	Harmonic Generator	R712, R708, C712	Distorted stereophonic information, due to baseband second harmonic.
V703 V704	7543	Balanced Modulator	R719, R729, C709 38 kc BAL	Excessive carrier and baseband unbalance.
V705	7199	Differential Amp.	None	Weak, distorted, or no stereophonic output. Distortion due to baseband second harmonic.
V801	12AU7A	19 kc Cath. Fol. (V801A)	None	Weak, distorted, or no 19 kc output.
		38 kc Cath. Fol. (V801B)	None	Weak, distorted, or no stereophonic output.
V802	12AT7	19 kc Cath. Fol. (V802A)	None	Excessive, distorted 19 kc output.
		19 kc Xtal Osc. (V802B)	None	Weak or no 19 kc output. Weak or no stereophonic output. Oscillators unlocked.
V803	12AT7	38 kc Cath. Fol. (V803A)	None	Excessive, distorted stereophonic output.
		38 kc Locked Osc. (V803B)	None	Weak or no stereophonic output.
V901	8-4	Filament Regulator	None	No stereophonic output. No 38 kc residual output.
V902	6DR7	Series Volt. Reg (V902A)		All outputs weak or distorted. No carrier balance. B + low.
		Volt. Reg. Amp. (V902B) Output	B+ ADJ.	Excessive stereophonic, 19 kc outputs. B + high.
V903	6DR7	Series Volt. Reg. (V903A)		Same as V902A. B + low.
		Volt. Reg. Amp. (V903B) Input	B+ ADJ.	Same as V902A. B + low.
V904	OG3	Voltage Reference	B+ ADJ.	Same as V902B. B + high.
V905	8-4	Filament Regulator	None	Same as V901.
*V906	6X4	Rectifier, Negative Supply	None	Weak or no stereophonic output. Weak or no 19 kc output.
CR905	82V	Zener, Negative Supply	None	Excessive, weak, or no stereophonic output. No carrier balance. Excessive, weak, or no 19 kc output.

**V906 (6X4) must be replaced with a 6X4 ONLY; a 6X4W will cause hum in the (L-R) signal.*

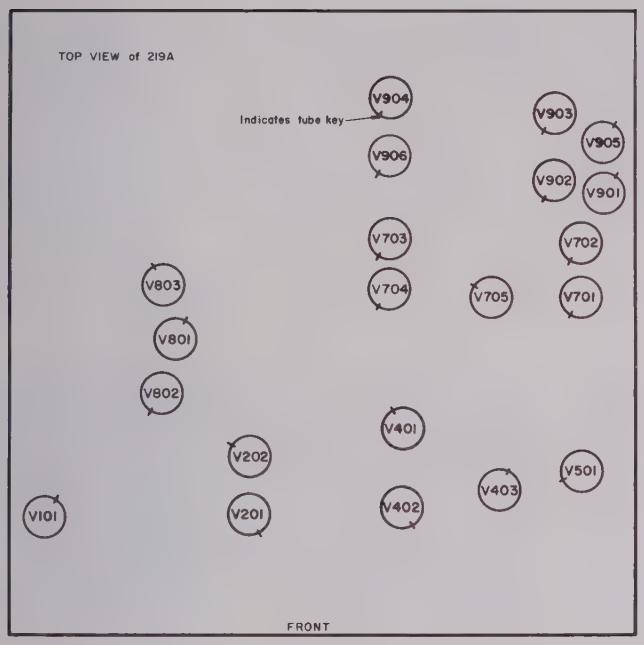


Figure 16. Tube Location Diagram

MECHANICAL DISASSEMBLY PROCEDURES

Top and Bottom Covers

1. Remove four screws in each cover.
2. Slide cover toward rear of instrument to disengage rear foldover of cover.

Right and Left Side Covers

There are two covers on each side of the instrument. Each cover is held in place with two screws which may be removed without removing the top or bottom cover. On some instruments, four screws and nuts are used.

Front Panel

1. Remove top and bottom covers.
2. Remove four side covers (left and right).
3. Remove adhesive trim strips from right and left side frames to expose three flathead screws on each side. Remove these screws.
4. Loosen side frames by removing four screws securing chassis on each side of the instrument. Screws holding side frames to back panel may be left in place.
5. Spring out side frames. Front panel may be moved forward though restricted by connecting wires. This will provide sufficient clearance for replacement of parts.

Deviation Meter

1. Remove top cover.
2. Remove right front side cover.
3. Unsolder two leads attached to terminal board on meter which come from under the chassis.
4. Remove nuts securing the terminal board to the back of the meter.
5. Move terminal board out of the way to remove the nuts from the studs at each corner of the meter movement.
6. Slide deviation meter out of the front panel.

ADJUSTMENT AND CALIBRATION

Any tolerances listed in this section are the limits indicated by the Specifications in Section II. Factory adjustments are made to considerably closer tolerances corresponding to standard practice in the industry. Field adjustments to closer than specified tolerances are possible if time and patience are used. Fig. 18 shows location of all test and alignment points indicated in these procedures.

Recommended Equipment List

The following instruments are recommended for use in the adjustment and calibration of the 219A. Pertinent information is given for substitution purposes.

1. -hp- 412A dc VTVM
Range: 1 mv to 1000 v (full range not required)
Accuracy: ±1% full scale

2. -hp- 400H ac VTVM
Range: 1.0 mv to 300 v
Frequency Range: 10 cps to 4 mc
Accuracy: ± 1% 50 cps to 500 kc
± 5% 10 cps to 4 mc

3. -hp- 330B Distortion Analyzer
Frequency Distortion Range: 20 cps to 20 kc
Accuracy: ± 3%
Input Level: At least 1 v rms

4. -hp- 5243L Electronic Counter
Frequency Range: 0 cps to 20 mc

5. -hp- 130C Oscilloscope
Sensitivity: 0.2 mv/cm
Frequency Range: 0 to 500 kc
Input Impedance: 1 megohm shunted by 45 pf

NOTE: Excessive capacitance at oscilloscope input and in cable connections can affect oscilloscope patterns. For the oscilloscope patterns in this manual a maximum capacitance of 200 pf was observed.

6. -hp- 310A Wave Analyzer
Frequency Range: 1 kc to 1.5 mc (200 cps passband)
Accuracy: ± (1% + 300 cps)
Voltage Range: 10 μv to 100 v full scale
Accuracy: ± 6% full scale

7. -hp- 201C Audio Oscillator
Frequency Range: 20 cps to 20 kc
Accuracy: ± 1%
Output into 600 Ω: 3 watts (42.5 v)
Distortion: .03% maximum

8. -hp- 11004A Line Matching Transformer (Formerly AC-60A)

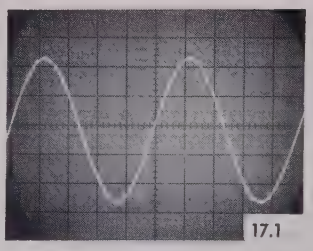
9. -hp- 204B Audio Oscillator
Frequency Range: 5 cps to 560 kc (full power range not required)
Accuracy: ± 3%
Output into 600 Ω: 10 mw (2.5 v rms)
Distortion: Less than 1%

The oscilloscope patterns were photographed with the 219A set up as follows unless otherwise specified:

Control	Setting
CHANNEL	NORMAL
PRE-EMPH	OUT
MATRIX	NORMAL
OUTPUT MODE	MULTIPLEX
19 kc Oscillator	On
19 kc level	10%
1 kc Oscillator	ON
1 kc level	45% in the L+R and L−R positions of the OUTPUT MODE switch
OUTPUT	Maximum CW (full on)

Code for Captions

1. Description:
2. Oscilloscope connected to:
3. Oscilloscope Sync Frequency:
4. Oscilloscope sensitivity:
5. Remarks


17.1

1. 1 kc Internal Oscillator output
2. Right Input Terminals
3. 1 kc
4. 1 v/cm
5. —

Same as Fig. 17.1 except level is approximately .98 v p-p

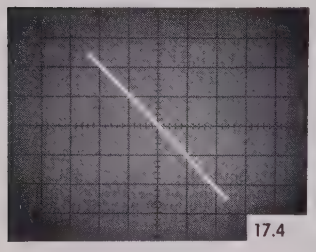
17.2

1. Output of 1 kc Oscillator
2. TP101
3. 1 kc
4. —
5. 180° out of phase with Fig. 17.3

Same as Fig. 17.6 except level is approximately .98 v p-p

17.3

1. Output of 1 kc Oscillator
2. TP102
3. 1 kc
4. —
5. 180° out of phase with Fig. 17.2

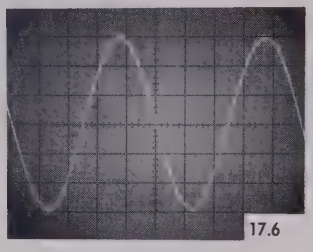

17.4

1. Phase relation between TP101 and TP102
2. TP101 to Horizontal input and TP102 to Vertical input
3.
4. H and V — 0.2 v/cm
5. —

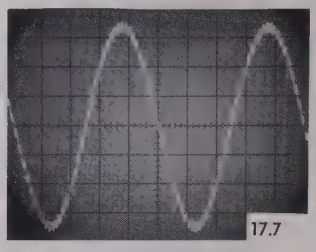
Same as Fig. 17.1 except level is approximately 22 v p-p

17.5

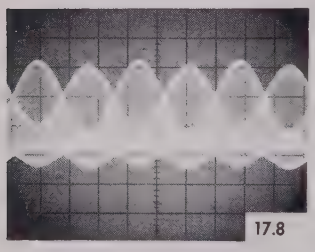
1. 1 kc signal on Oscillator Amplifier Plate
2. Pin # 9 of V101
3. 1 kc
4. —
5. —


17.6

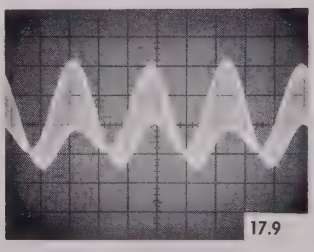
1. L+R Adder Amplifier Output
2. TP201
3. 1 kc
4. 0.2 v/cm
5. —


17.7

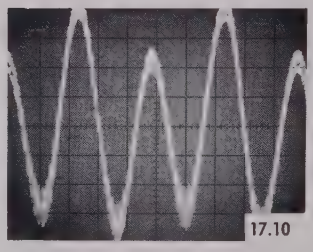
1. L−R difference Amplifier Output
2. TP202
3. 1 kc
4. 0.2 v/cm
5. —


17.8

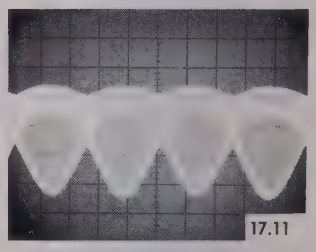
1. Modulator Output
2. TP701
3. 1 kc
4. 0.5 v/cm
5. —


17.9

1. Balanced Modulator Output
2. TP701
3. 19 kc
4. 0.5 v/cm
5. Same as Fig. 17.8 except for 19 kc sync.


17.10

1. Harmonic Generator Output
2. TP702
3. 1 kc
4. 10 mv/cm
5. —

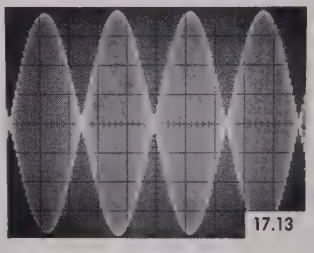

17.11

1. Balanced Modulator Output
2. TP703
3. 1 kc
4. 0.1 v/cm
5. —

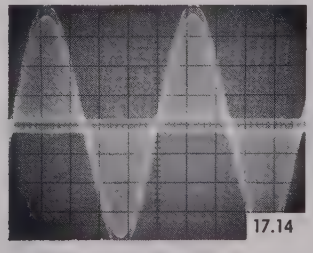
Same as Fig. 17.24 except level is approximately .42 v p-p

17.12

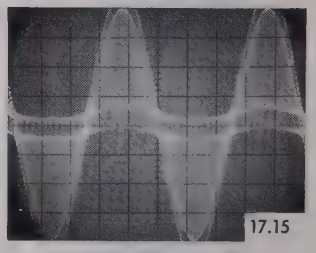
1. 38 kc Output
2. TP704
3. 19 kc
4. —
5. —


17.13

1. Output of the (L—R) Bandpass Filter
2. Output of the (L—R) Bandpass Filter
3. 1 kc
4. 0.2 v/cm
5. —

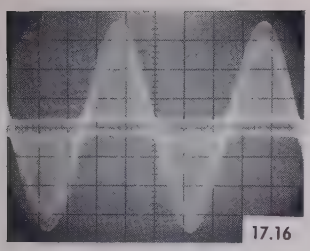

17.14

1. Output of (L—R) and (L+R) Amplifiers
2. Junction of R411, R412, and R413
3. 1 kc
4. 50 mv/cm
5. —

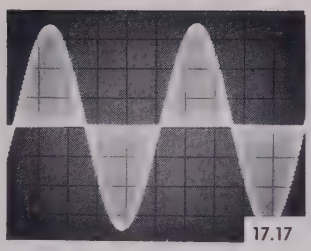

17.15

1. Multiplex Signal to Output Tube
2. Pin #2 of V402
3. 1 kc
4. 2 v/cm
5. Wavy base line due to loading by oscilloscope leads

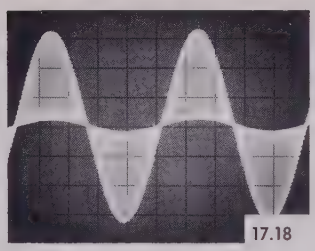
Figure 17. Waveforms Chart



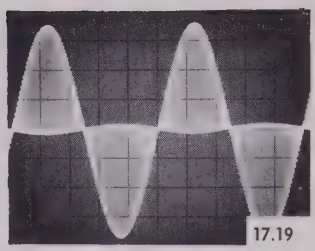
1. Multiplex Output
2. Output Terminals of the 219A
3. 1 kc
4. 2 v/cm
5. 1 kc signal on right channel only



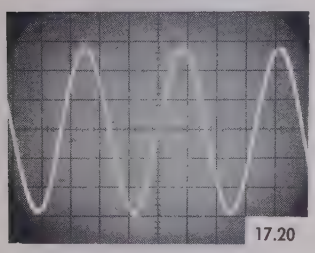
1. Multiplex Output
2. Output Terminals of the 219A
3. 1 kc
4. 2 v/cm
5. Same as Fig. 17.16 with 19 kc off



1. Multiplex Output — L—R GAIN misadjusted
2. Output Terminals of the 219A
3. 1 kc
4. 2 v/cm
5. Misadjustment: Insufficient (L—R) gain (19 kc off)



1. Multiplex Output — L—R GAIN misadjusted
2. Output Terminals of the 219A
3. 1 kc
4. 2 v/cm
5. Misadjustment: Excessive (L—R) gain (19 kc off)

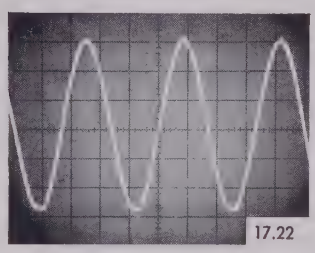


1. 19 kc Oscillator Output
2. Pin #6 of V802
3. 19 kc
4. 1 v/cm
5.

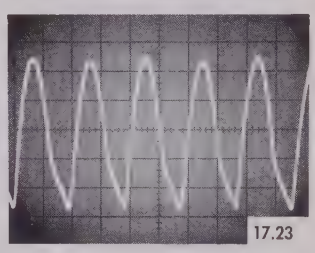
Same as Fig. 17.20 except level is approximately 5.3 v p-p

17.21

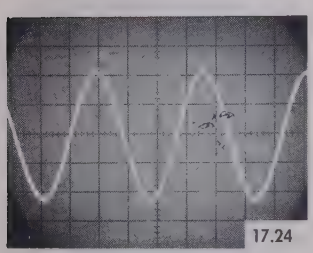
1. 19 kc Output
2. TP801
3. 19 kc
4.
5.



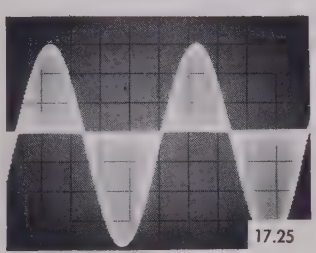
1. 19 kc Sync Output
2. 19 kc Output Jack
3. 19 kc
4. 0.2 v/cm
5. Note slight distortion on lower peak.



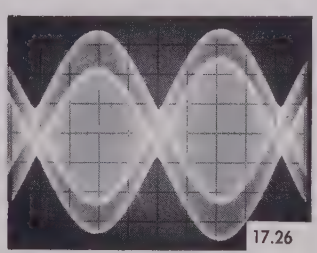
1. Output of Frequency Doubler
2. Center Arm of R830
3. 19 kc
4. 0.2 v/cm
5.



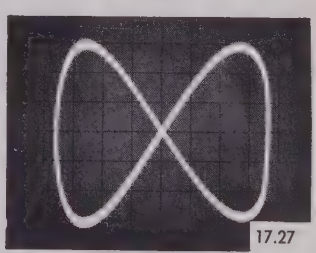
1. 38 kc Oscillator Output
2. Pin #3 of V801
3. 19 kc
4. 2 v/cm
5. ——



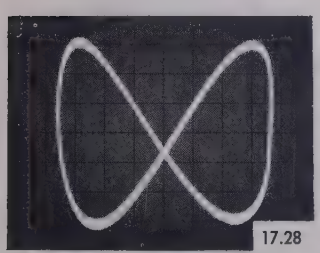
1. Multiplex Output — 38 kc misadjusted
2. Output Terminals of the 219A
3. 1 kc
4. 2 v/cm
5. Misadjustment: 38 kc out of balance (19 kc off)



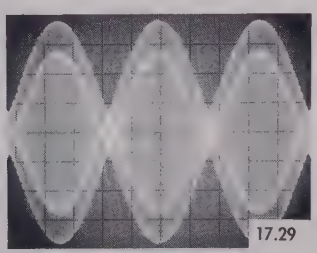
1. (L –R) Output — Phase misadjusted
2. Output Terminals of 219A
3. 14 kc
4. 2 v/cm
5. Misadjustment: Phase relation between 19 kc and 38 kc incorrect (Output Mode Switch—L R)



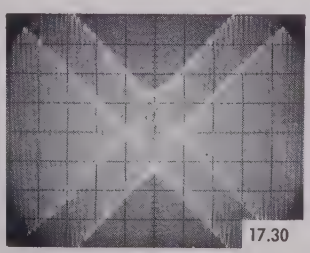
1. Phase relation: 19 to 38 kc (Correct)
2. Output of 219A to Vertical Input (Output Mode switch — L—R) — 19 kc Output to Horizontal
3. ——
4. ——
5. Loops should be of equal height with cross-over in center.



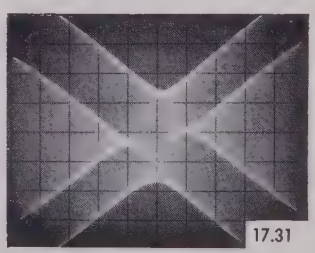
1. Same as Fig. 17.27 except incorrect phase.
2. See Fig. 17.27
3. ——
4. ——
5. Note cross-over not in center.



1. (L—R) Output
2. Output Terminals of the 219A
3. 1 kc
4. 1 v/cm
5. Output Mode switch in (L—R) position



This display is the same as Fig. 17.29 except that the horizontal and vertical gain of the oscilloscope has been increased to show the base line intersections.



This display is the same as Fig. 17.26 except that the horizontal and vertical gain of the oscilloscope has been increased to show the base line intersections.

Figure 17. Waveforms Chart (continued)

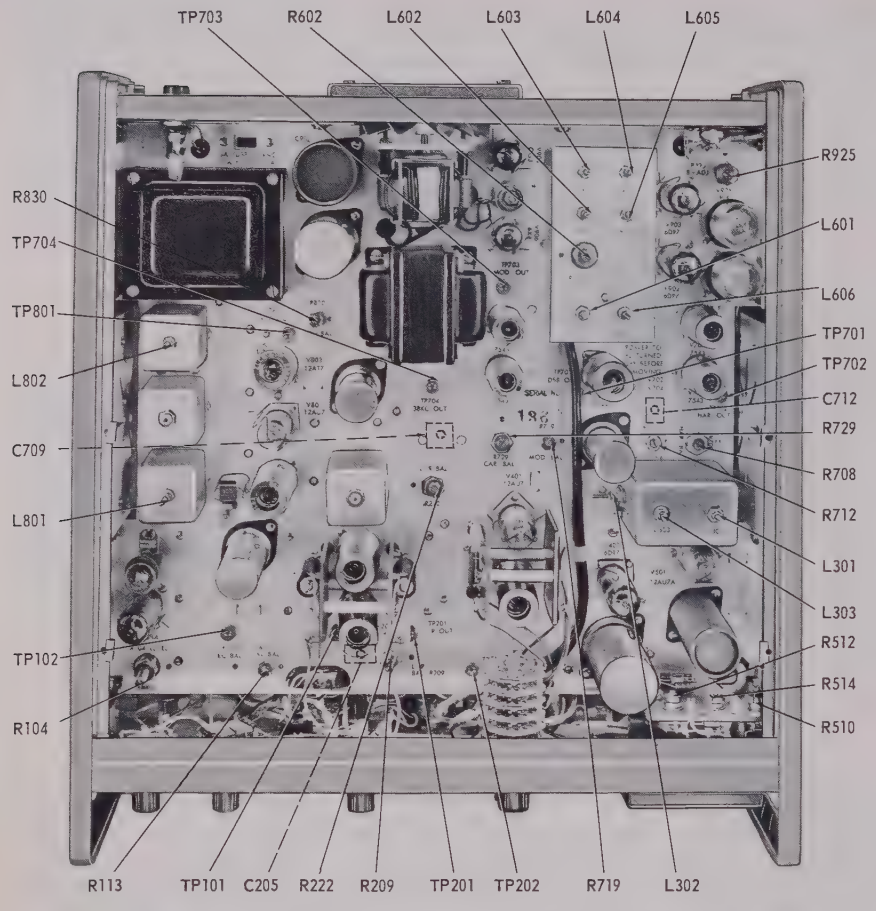


Figure 18. Test and Alignment Points Locations .

Power Supply

EQUIPMENT REQUIRED

1. -hp- 412A dc VTVM or equivalent*
2. -hp- 400H ac VTVM or equivalent*
3. Variable 60 cycle power source with meter

B+ Supply

PRELIMINARY SETUP

1. Connect the dc VTVM between the regulated B+ line (pin No. 2 or No. 3 of V705) and chassis ground.
2. Apply 115 vac to the power input of the 219A.

ADJUSTMENT

1. Meter reading on the dc VTVM should be 210 vdc. Adjust R925 (B+ Adj)[1] (Fig. 18) if the voltage is incorrect.
2. Check voltage after warmup. Readjust R925 if necessary.
3. Vary the input voltage to the 219A from 105 to 125 vac. DC output voltage should not change more than ± 1.5 vdc.
4. Connect the ac VTVM (or an oscilloscope) at the same point as the dc VTVM. Ripple should not exceed 1 mv (2.5 mv peak-to-peak on the oscilloscope) over the input range of 105 to 125 vac.
5. Connect the ac VTVM to the −82 vdc line (junction of R907 and CR905) and chassis ground. Ripple voltage must not exceed 5 mv.
6. Connect the dc VTVM to pin No. 6 of V701, V702, V703, or V704. This screen voltage should be 50 ± 5 vdc.

Filament Suppy Check

PRELIMINARY SETUP

1. Connect the ac VTVM between the filament lines (pins 3 and 4 of V701).
2. Set input voltage to 115 vac.

CHECK

1. The filament voltage on the filament lines should be 6.3 ± 0.3 vac.
2. Vary the input voltage from 105 to 125 vac. The filament voltage should not change more than 0.6 vac.

1 kc Oscillator

EQUIPMENT REQUIRED

1. -hp- 400H ac VTVM or equivalent*
2. -hp- 5243L Electronic Counter or equivalent*
3. -hp- 330B Distortion Analyzer or equivalent*

PRELIMINARY SETUP

1. Set front panel controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	OUT
MATRIX	NORMAL
19 kc	Off (pushed in)
OUTPUT MODE Switch	SET
1 kc Switch	not significant
1 kc Control	See Adjustment
OUTPUT Control	Maximum clockwise

2. Connect a 1.5 k ohm, 1 watt resistor across the output terminals of the 219A.
3. Connect the ac VTVM (or an oscilloscope) across the output terminals.

ADJUSTMENT

1. Adjust the 1 kc control until the ac VTVM reads 5.3 v rms (15 v peak-to-peak on the oscilloscope).
2. Adjust R514 (see Fig. 18) on the 219A for a 100% panel meter reading.
3. Rotate 1 kc switch to ON position.
4. Change the OUTPUT MODE switch to the L + R position. Adjust R104 (see Fig. 18) until the panel meter on the 219A reads 50 to 55% with the 1 kc control in the maximum clockwise position.

**See Recommended Equipment List under Adjustment and Calibration*

5. Connect the electronic counter to the RIGHT INPUT terminals. The frequency at these terminals should be 1000 cps ± 10%.

6. Remove counter and connect the distortion analyzer to the RIGHT INPUT terminals. The distortion at these terminals should be less than 1%.

19 kc Crystal Oscillator

EQUIPMENT REQUIRED

1. -hp- 400H ac VTVM or equivalent*
2. -hp- 5243L Electronic Counter or equivalent*
3. -hp- 130C Oscilloscope or equivalent*

PRELIMINARY SETUP

1. Set Controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	OUT
MATRIX	NORMAL
19 kc Switch	On (pulled out)
19 kc Control	See Adjustment
OUTPUT MODE Switch	19 kc
1 kc Switch	OFF
OUTPUT Control	Maximum clockwise

2. Connect the ac VTVM to TP801 (See Fig. 18).

ADJUSTMENT

1. Adjust L801 (See Fig. 18) for a maximum reading on the ac VTVM. The voltage should be between 1.25 v and 3 v rms.

2. Remove the ac VTVM and connect the electronic counter to TP801 (See Fig. 18). The frequency at this test point should be 19 kc ± .01%.

3. Remove the electronic counter and connect the ac VTVM across the OUTPUT terminals of the 219A (1.5K ohm load resistor should be connected across terminals).

4. Adjust the 19 kc control until the ac VTVM reads 0.530 v rms.

5. Adjust R510 (See Fig. 18) until the 219A panel meter reads 10%.

6. Change the ac VTVM connection to the 19 kc Output Jack at the rear of the instrument. The voltage at this jack should be at least 0.3 v rms.

NOTE: The 19 kc output from the rear of the 219A is for oscilloscope synchronization. Distortion observed on this jack is normal (See Fig. 17.22).

7. Connect the oscilloscope to the center arm of R830 (See Fig. 18) and connect the oscilloscope sync input to the 19 kc output on the rear of the instrument.

8. Adjust R830 (Fig. 18) for minimum 19 kc which will give maximum equality of peaks (See Fig. 17.23).

9. Change the OUTPUT MODE switch to the MULTIPLEX position. The 19 kc control should be capable of increasing the 19 kc output at the OUTPUT terminals until panel meter reads 30%.

38 kc Locked Oscillator

EQUIPMENT REQUIRED

-hp- 130C Oscilloscope or equivalent*

PRELIMINARY SETUP

1. Set front panel controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	OUT
MATRIX	NORMAL
19 kc Switch	Off (pushed in)
OUTPUT MODE Switch	L − R
1 kc Switch	OFF
OUTPUT Control	Maximum clockwise

2. Connect the oscilloscope vertical input to the OUTPUT terminals of the 219A. Connect the oscilloscope horizontal INPUT to the 19 kc Output Jack. Shift the 38 kc slightly off balance (Use front panel screwdriver adjustment.).

ADJUSTMENT

1. With oscilloscope pattern (Fig. 17.28), adjust L802 (Fig. 18) for most symmetrical shape (Fig. 17.27). (This is the coarse adjustment. Fine adjustment is made in this section under Overall Check and Final Adjustment, step 8).

2. Change the oscilloscope connection to TP704 (Fig. 18). Voltage at this test point should be 0.4 to 0.5 v peak-to-peak (Fig. 17.12).

L + R (V201) Balance Adjustment

EQUIPMENT REQUIRED

1. -hp- 201C Audio Oscillator or equivalent*
2. -hp- 130C Oscilloscope or equivalent*
3. -hp- 11004A Line Matching Transformer* (formerly -hp- AC-60A)
4. Matched pair of 300-ohm precision resistors (matched within 0.5% of each other).

PRELIMINARY SETUP

1. Set front panel controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	OUT
MATRIX	NORMAL
19 kc Switch	Off (pushed in)
OUTPUT MODE Switch	L + R
1 kc Switch	OFF
OUTPUT Control	Maximum clockwise

2. Connect the equipment as shown in Fig. 19.

3. Adjust C205 (See Fig. 18) to minimum capacity.

4. Connect transformer to the RIGHT INPUT terminal only.

5. Set audio oscillator to 1 kc and adjust output until panel meter on the 219A reads 45%.

ADJUSTMENT

1. By alternately connecting the transformer to the RIGHT and LEFT INPUT terminals, adjust R209 (See Fig. 18) for coarse equality.

2. Connect the transformer across the RIGHT and LEFT INPUT terminals. This puts an (L — R) signal with L = -R at the 219A INPUT. Output level, as indicated on the oscilloscope, should decrease by more than 40 db.

3. Remove the transformer. Change MATRIX switch to L — R NULL. Adjust R113 (See Fig. 18) for minimum signal on the oscilloscope.

L − R (V202) Balance Adjustment

EQUIPMENT REQUIRED

1. -hp- 201C Audio Oscillator or equivalent*

**See Recommended Equipment List under Adjustment and Calibration*

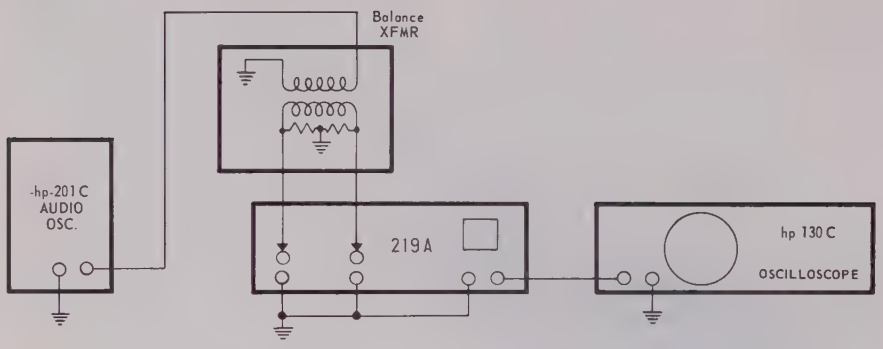


Figure 19. (L + R) Balance Adjustment Setup

2. -hp- 130C Oscilloscope or equivalent*

PRELIMINARY SETUP

1. Set front panel controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	OUT
MATRIX	NORMAL
19 kc Switch	Off (pushed in)
1 kc Switch	OFF
OUTPUT MODE Switch	L — R
OUTPUT Control	Maximum clockwise

2. Connect audio oscillator with 10 kc output to LEFT INPUT terminals.

3. Connect the oscilloscope to TP-202 (See Fig. 18). Short TP 704 (See Fig. 18) to ground. Adjust audio oscillator for full scale reading on the oscilloscope.

4. Connect a jumper across the INPUT terminals of the 219A. This puts an (L + R) signal with L = R at the 219A INPUT

ADJUSTMENT

1. Slowly adjust R222 (See Fig. 18) for minimum 1 kc.

2. Remove short from TP704. Remove audio oscillator connections.

3. Change MATRIX switch to L — R NULL and check for proper operation.

Balanced Modulator Balance Adjustment

EQUIPMENT REQUIRED

1. -hp- 201C Audio Oscillator or equivalent*

2. -hp- 310A Wave Analyzer or equivalent*

PRELIMINARY SETUP

1. Set controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	OUT
MATRIX	NORMAL
19 kc Switch	Off (pushed in)
OUTPUT MODE Switch	L + R
1 kc Switch	OFF
OUTPUT Control	Maximum clockwise
38 kc BAL	Mid-range position

2. Connect audio oscillator to right input terminals. At a frequency of 10 kc, adjust oscillator output to read 45% on panel meter of the 219A. Connect the oscilloscope, the wave analyzer, and a 1.5K ohm resistor across the OUTPUT terminals of the 219A. The oscilloscope sync input should be connected to the 19 kc output jack on the 219A.

3. Change the OUTPUT MODE switch to the 38 kc position.

ADJUSTMENT

1. Adjust R729 (See Fig. 18) for minimum oscilloscope deflection.

2. Adjust C709 (See Fig. 18) for minimum oscilloscope deflection.

3. Repeat steps 1 and 2 to assure minimum response.

4. If the 19 kc output is high at this point, readjust R830 (See 19 kc Crystal Oscillator, step 5).

5. Change setup as follows:

a. OUTPUT MODE switch to L — R position.

b. Oscilloscope sync to 10 kc audio oscillator output.

c. Short TP702 to ground with 10 μf, 450 volt capacitor.

d. Set wave analyzer to 10 kc.

6. Adjust R719 (See Fig. 18) for minimum 10 kc, as indicated by the wave analyzer.

7. Change setup as follows:

a. Remove shorting capacitor from TP702.

b. Short TP703 to ground with 10 μf capacitor.

8. Adjust R712 (See Fig. 18) for minimum 10 kc, as indicated by the wave analyzer.

9. Remove shorting capacitor.

10. Tune the wave analyzer to 28 kc (38 kc subcarrier minus 10 kc sideband). Adjust analyzer until analyzer meter reads 0 db.

11. Tune wave analyzer to 38 kc. Readjust R729 and C709 (See Fig. 18) for minimum 38 kc.

12. Tune wave analyzer to 10 kc and repeat steps 5 through 8 until no further reduction in 10 kc results. Remove shorting capacitor.

13. Tune wave analyzer to 20 kc (2nd harmonic of input signal). To identify the 20 kc signal, momentarily switch off the 10 kc input to the 219A. The 20 kc signal, if present, will disappear. Adjust R708 and C712 (See Fig. 18) for minimum 20 kc.

14. Tune wave analyzer to 114 kc. Adjust L604 (See Fig. 18) for minimum.

15. Tune wave analyzer to 76 kc. Adjust L601 and R602 (See Fig. 18) for minimum.

16. Tune the wave analyzer to the following frequencies and check signal level at each frequency. The level on the wave analyzer should be equal to, or less than, the level shown, except as noted.

Frequency	*Signal Level*
10 kc (Fundamental—input signal)	—50 db
18 kc	—46 db
19 kc (Pilot carrier)	—56 db
20 kc (2nd Harmonic of Input signal)	—60 db

**See Recommended Equipment List under Adjustment and Calibration*

Frequency	*Signal Level*
28 kc	0 db
38 kc (Subcarrier)	−50 db
48 kc	0 db (± 0.5 db)
57 kc	−50 db
58 kc	−46 db
66 kc	−32 db
76 kc (2nd Harmonic of Subcarrier)	−56 db
86 kc	−32 db
114 kc	−56 db

Phase and Amplitude Equalization

EQUIPMENT REQUIRED

1. -hp- 201C Audio Oscillator or equivalent*

2. -hp- 130C Oscilloscope or equivalent*

PRELIMINARY SETUP

1. Set front panel controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	OUT
MATRIX	NORMAL
19 kc Switch	Off (pushed in)
OUTPUT MODE Switch	L + R
1 kc Switch	OFF
OUTPUT Control	See step 5

2. Connect audio oscillator with 10 kc output to the RIGHT INPUT terminals of the 219A. Connect the oscilloscope and a 1.5K ohm resistor to OUTPUT terminals of the 219A.

NOTE: Excessive capacitance at output terminals shows up as unwanted phase shift. During tests unnecessary leads or equipment should not be connected to these terminals.

3. Adjust audio oscillator level to give 45% reading on panel meter.

4. Change OUTPUT MODE switch to L — R position. Adjust L — R GAIN (front panel screwdriver adjustment) for 45% reading on the panel meter.

5. Change the OUTPUT MODE switch to the MULTIPLEX position. Set the OUTPUT control for full scale deflection on the oscilloscope (oscilloscope vertical gain—.1v/cm). The oscilloscope pattern should approximate the pattern in Fig. 17.17.

ADJUSTMENT

1. Adjust L — R GAIN (front panel screwdriver adjustment) for flattest base line as shown in Fig. 17.17). Fig. 17.19 shows pattern with excessive (L — R) gain and Fig. 17.18 shows pattern with insufficient (L — R) gain.

2. Recheck (L — R) at 50 cps.

3. Recheck (L — R) gain adjustment at 5 kc. Check phase shift. Adjust phase shift at 5 kc with L303 (See Fig. 18) for minimum.

4. Change the audio oscillator frequency to 15 kc. Adjust L302 (See Fig. 18) for minimum phase shift as indicated by Fig. 17.17.

5. Recheck (L — R) gain and phase relationship at 5 kc, 10 kc, and 15 kc with the audio oscillator connected to the LEFT channel. Adjust C205 (See Fig. 18) for best compromise between LEFT and RIGHT inputs.

NOTE: If (L — R) gain relative to (L + R) gain decreases above 12 kc, L301 has too much inductance. Back out L301 adjustment (counterclockwise) about three turns and repeat steps 3 and 4.

The peak-to-peak height variation of (L + R) or (L — R) signals must not be more than ±.5% over the range of 50 cps to 15 kc with input amplitude to the 219A held constant.

Overall Check and Final Adjustment

EQUIPMENT REQUIRED

1. -hp- 400H ac VTVM or equivalent*

2. -hp- 130C Oscilloscope or equivalent*

3. -hp- 201C Audio Oscillator or equivalent*

4. -hp- 330B Distortion Analyzer or equivalent*

PRELIMINARY SETUP

1. Set front panel controls as follows:

Control	*Position*
CHANNEL	NORMAL
PRE-EMPH	OUT
MATRIX	NORMAL
19 kc Switch	Off (pushed in)
OUTPUT MODE Switch	SET
1 kc Switch	not significant
1 kc Control	Adjust for 100% reading on panel meter.
OUTPUT Control	Maximum clockwise (full on)

2. Connect the ac VTVM and a 1.5K ohm resistor across the OUTPUT terminals of the 219A.

CHECK

1. Voltage at the output terminals should be 5.3 v rms nominally.

2. Change the front panel controls as follows:

a. OUTPUT MODE switch to the L + R position.

b. 1 kc switch to ON.

c. 1 kc control to be adjusted for a 45% reading on the panel meter.

3. Change the ac VTVM connections from the output terminals to the RIGHT INPUT terminals. The reading on the ac VTVM should be a maximum of 2.3 v rms.

4. Change the OUTPUT MODE switch to the L — R position. Adjust L — R GAIN (front panel screwdriver adjustment) for 45% reading on the panel meter.

5. Change the OUTPUT MODE switch to the 38 kc position. Adjust 38 kc BAL (front panel screwdriver adjustment) for null.

6. Change the OUTPUT MODE switch to the 19 kc position. Turn on 19 kc pilot carrier (control knob pulled out) and adjust the control for 9% reading on the panel meter.

7. Change the OUTPUT MODE switch to the MULTIPLEX position. The panel meter should read 97.1% nominally.

8. Change the MATRIX switch to the L + R null position. Connect oscilloscope to 219A OUTPUT terminals. Fig. 17.29 shows oscilloscope pattern. By expanding the pilot carrier and modulator output base line zero crossings, the pattern of Fig. 17.30 will result. Adjust L802 for exact crossing configuration if not correct.

9. Change the front panel controls as follows:

a. 19 kc switch to the off position (control knob pushed in).

**See Recommended Equipment List under Adjustment and Calibration*

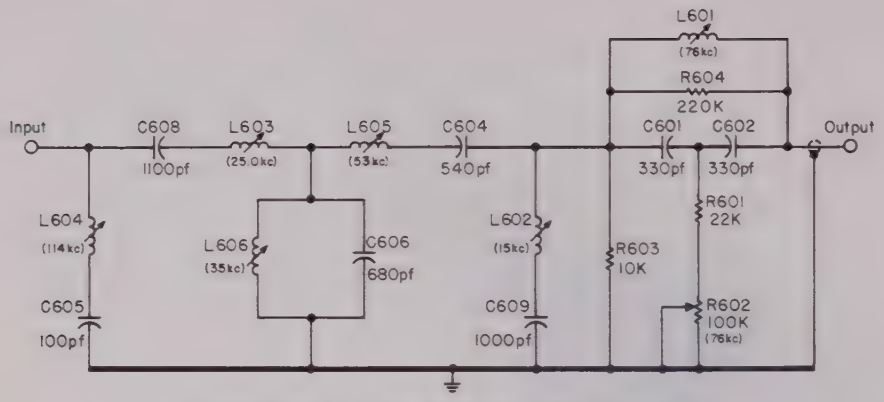


Figure 20. (L — R) Bandpass Filter Circuitry

b. OUTPUT MODE switch to the L + R position.

c. 1 kc switch to OFF.

10. Connect the audio oscillator at a frequency of 1 kc to the RIGHT INPUT terminals. Adjust the output of the audio oscillator for a 100% reading on the panel meter.

11. Connect the distortion analyzer to the output terminals of the 219A (Do not use the 1.5K ohm load resistor). Distortion plus residual signals should be less than 0.5% as read on the distortion analyzer.

12. Disconnect the audio oscillator. The residual signals should be less than 0.1% as read on the distortion analyzer.

L — R Bandpass Filter Alignment Procedure

The (L — R) Bandpass Filter is a separable component of the 219A. It may be completely removed for maintenance, repair or alignment as follows:

1. Disconnect shielded cable from filter to rear deck of the OUTPUT MODE switch (S401G) by unsoldering leads at the switch.

2. Disconnect the blue lead from the filter to pin No. 1 of V705 by unsoldering lead at tube socket.

3. Remove the three nuts and lockwashers from the underside of the chassis which secure the filter shield cover. Remove the screw in the cable clamp near the OUTPUT MODE switch.

4. Lift out the filter carefully to avoid damage when pulling the blue lead through the chassis.

EQUIPMENT REQUIRED

1. -hp- 204B Audio Oscillator or equivalent*
2. -hp- 130C Oscilloscope or equivalent (or -hp- 400H ac VTVM or equivalent)*
3. .1 μf, ±5% capacitor
4. 10 pf capacitor
5. 10KΩ resistor
6. Clip Leads

PRELIMINARY SETUP

Fig. 20 shows the circuitry of the filter.

The audio oscillator and oscilloscope (or ac VTVM) are connected as indicated in the following Alignment Chart.

**See Recommended Equipment List under Adjustment and Calibration*

Step No.	Audio Oscillator Connected	Osc. Freq.	Oscilloscope (or ac VTVM) Connected	Adjust	For	Remarks
1.	With 10KΩ series resistor to junction of L603-L605 and ground.	2.8 kc	To Junction of L603-L605 and ground.	L606	Max. output	Connect .1 — 5% capacitor across L606.
2.	Junction of L601-L602 and ground.	53 kc	With 10 pf series capacitor to junction of L605-C604 and ground.	L605	Max. output	Short L606 with clip lead.
3.	With 10KΩ series resistor to filter input	25 kc	With 10 pf series capacitor to junction of C608-L603 and ground.	L603	Max. output	Short L606 with clip lead.
4.	With 10KΩ series resistor to filter input.	14 kc	To Filter Output.	L602	Null	
5.	With 10KΩ series resistor to filter input.	114 kc	To Filter output.	L604	Null	
6.	With 10KΩ series resistor to filter input.	76 kc	To Filter output.	L601 R602	Null	

ALIGNMENT CHART — (L — R) BANDPASS FILTER

L — R Bandpass Filter Calibration Check

EQUIPMENT REQUIRED

1. -hp- 204B Audio Oscillator or equivalent*
2. -hp- 400H ac VTVM or equivalent*
3. 10K ohm resistor
4. Clip Leads

PRELIMINARY SETUP

Connect the audio oscillator to the input of the filter through a 10K ohm resistor. Remove all clips and shorting devices. Connect the ac VTVM to the output of the filter. Set the audio oscillator at 38 kc and adjust the output to read 0 db on the ac VTVM.

CHECK

Starting at 1 kc, increase the audio oscillator frequency and check the meter readings in db against the typical response curve shown in Fig. 21. It should be noted that the response between the frequencies of 23 kc and 53 kc should be flat within ±0.2 db.

**See Recommended Equipment List under Adjustment and Calibration*

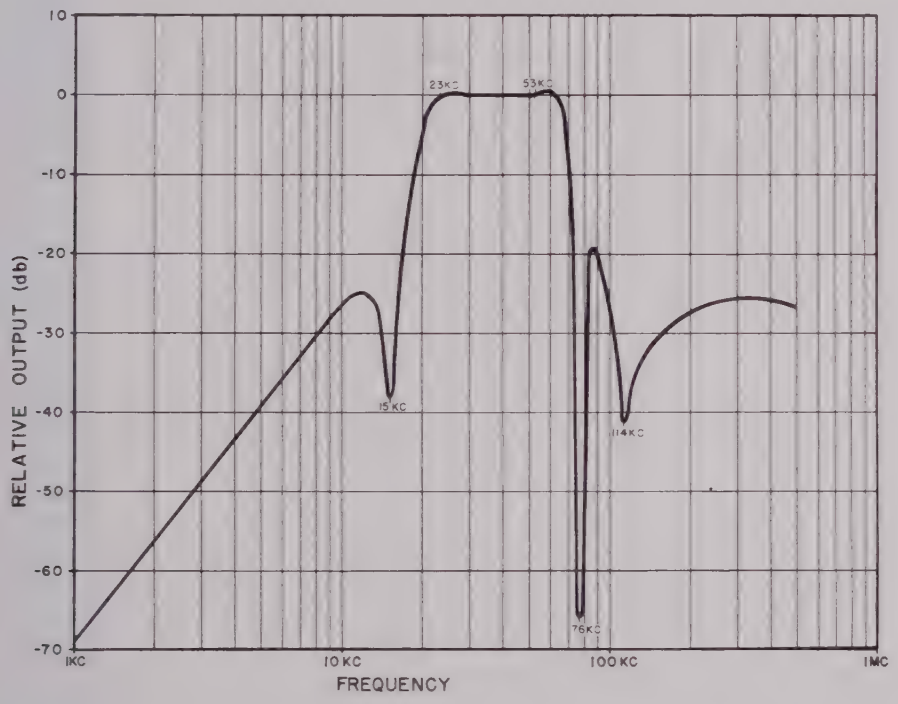


Figure 21. Typical Curve — 219A (L — R) Bandpass Filter

SECTION VII
REPLACEMENT PARTS

GENERAL

Tables of replaceable electrical and mechanical parts for the 219A are included in this section. Locations of these parts are given in Fig. 22 through 25, inclusive. When ordering replacement parts, specify the BRC part number and the description given in the replacement parts tables. See Section VI — MAINTENANCE for detailed disassembly and assembly procedures and for the adjustment and/or calibration procedures required after component replacement.

For convenience in obtaining replacement parts locally, a List of Manufacturers is given below. This list is keyed into the tables of replaceable parts where the manufacturer's type numbers are also given. When a manufacturer's code and type number are not given, the part is a special part manufactured by or for BRC.

LIST OF MANUFACTURERS

Code	Manufacturer's Name
AB	Allen-Bradley Company
AC	Astron Corporation
AEI	Arco Electronics, Inc.
AER	Aerovox Corporation
AH	Arrow-Hart & Hegemen Electric Co.
APC	Alden Products Company
C-D	Cornell-Dublier Electric Corp.
CEC	Corning Electronic Components, Corning Glass Works
CMC	Clarostat Mfg. Co., Inc.
CRL	Centralab Div. of Globe-Union, Inc.
CTS	CTS Corporation
EMC	Electro Motive Mfg. Co.
EMCO	Electra Mfg. Co.
ERC	Erie Resistor Corp.
FTC	Freed Transformer Co.
GA	Good-All Electric Mfg. Company
GE	General Electric Co.
GI	Grayhill, Inc.
H-P	Hewlett-Packard Co.
IRC	International Resistance Co.
LTF	Littelfuse, Inc.
MOT	Motorola Semiconductor Div., Motorola, Inc.
PRM	P. R. Mallory & Co.
SECO	Sangamo Electric Co.
SI	Switchcraft, Inc.
SPR	Sprague Electric Co.
TI	Texas Instruments, Inc.
TMC	Tower Mfg. Company
W-L	Ward Leonard Electric Co.

TABLE OF REPLACEABLE ELECTRICAL PARTS

CIRCUIT SYMBOL	VALUE	DESCRIPTION	BRC PART NO.	MFG.	MFG'S TYPE NO.
		1 KC OSCILLATOR			
C101, 102	1000 pf	Capacitor: Fixed, ±2%, 500V	82302	EMC	CM30 B102G
C103	8μf	Capacitor: Fixed, +50%, —10% 450V	83029	AER	PRS-EP
C104	.01μf	Capacitor: Fixed, ±20%, 300V	83123	GA	663A
C105, 106	.1μf	Capacitor: Fixed, ±20%, 400V	82456	GA	620M
C107	.47μf	Capacitor: Fixed, +80%, —20% 12V	146952	SPR	HY-330
C108	.1μf	Same as C105			
R101, 102	160KΩ	Resistor: Fixed, ±1%, ½W	80546	EMCO	DC½
R103	100KΩ	Resistor: Fixed, ±5%, 1W	80521	AB	GB
R104	1KΩ	Resistor: Variable, ±10%, 2W	81426	CMC	53M
R105	1.8KΩ	Resistor: Fixed, ±5%, 1W	80254	AB	GB
R106	1 Meg.Ω	Resistor: Fixed, ±5%, ½W	80621	AB	EB
R107	220KΩ	Resistor: Fixed, ±5%, ½W	80555	AB	EB
R108	47KΩ	Resistor: Fixed, ±5%, 2W	80494	AB	HB
R109	270Ω	Resistor: Fixed, ±5%, ½W	80232	AB	EB

CIRCUIT SYMBOL	VALUE	DESCRIPTION	BRC PART NO.	MFG.	MFG'S TYPE NO.
R110	15KΩ	Resistor: Fixed, ±5%, 4W	80434	AB	HM
R111	5KΩ	Resistor: Variable, (P/O S201)	308540		
R112	510Ω	Resistor: Fixed, ±5%, ½W	80129	AB	EB
R113	250Ω	Resistor: Variable, ±30%, 0.2W	81424	CTS	Type 70
R115	1 Meg.Ω	Same as R106			
RT101		Lamp: 3W, 120V	90907	GE	3S615
TP101, 102		Jack, Test: Red	89143	APC	110BC1
V101A, B		Tube, Electron: 6AU8A			
		L − R and L + R AMPLIFIER			
C201, 202	1500 pf	Capacitor: Fixed, ±2%, 500V	83169	EMC	CM20B-152G
C203	.47μf	Capacitor: Fixed, ±10%, 400V	82358	GA	663F
C204	12μf	Capacitor: Fixed, 250V	83135	C-D	12-250
C205	3-35 pf	Capacitor: Variable	84096	AEI	403
C206	8μf	Same as C103			
C207	12μf	Same as C204			
C208	.47μf	Same as C203			
C209	.022μf	Capacitor: Fixed, ±1%, 600V	145501	GA	620S
C210A, B	20-20μf	Capacitor: Fixed, 450V	83051	C-D	UP2245
J201		Binding Post: Red	304312	GI	29-1R
J202, 203		Binding Post: Black	304311	GI	29-1B
J204		Same as J201			
R201, 202	12KΩ	Resistor: Fixed, ±5%, ½W	80398	AB	EB
R203, 204	47KΩ	Resistor: Fixed, ±1%, ½W	80832	IRC	DCC
R205, 206	10KΩ	Resistor: Fixed, ±1%, ½W	80831	IRC	DCC
R207, 208	10KΩ	Resistor: Fixed, ±5%, 2W	80334	AB	HB
R209	10KΩ	Resistor: Variable, ±10%, 2W	81314	AB	Type JLU
R210	1 Meg.Ω	Same as R106			
R211, 212	1KΩ	Resistor: Fixed, ±5%, ½W	80148	AB	EB
R213	1 Meg.Ω	Same as R106			
R214	2.4KΩ	Resistor: Fixed, ±5%, 1W	80772	AB	GB
R215	2.2 Meg.Ω	Resistor: Fixed, ±5%, ½W	80649	AB	EB
R216	10KΩ	Resistor: Variable, ±10%, 2W	81429	CMC	53M
R220	1KΩ	Same as R211			
R221	10KΩ	Same as R207			
R222	10KΩ	Same as R209			
R223	1.74 Meg.Ω	Resistor: Fixed, ±1%, ½W	131510	TI	½PR
S201		Switch, 1 KC (P/O R111)	308540		
S202		Switch, CHANNEL	308543		
S203		Switch, PRE-EMPHASIS	308541		
S204		Switch, MATRIX	308542		
TP201, 202		Same as TP101			
V201A, B		Tube, Electron: 12AU7A			
V202A, B		Tube, Electron: 7199			
		L + R BAND PASS FILTER			
C301	470 pf	Capacitor: Fixed, ±5%, 500V	82229	EMC	CM20
C302	680 pf	Capacitor: Fixed, ±10%, 600V	82245	ERC	X5U681K

CIRCUIT SYMBOL	VALUE	DESCRIPTION	BRC PART NO.	MFG.	MFG'S TYPE NO.
C303	470 pf	Same as C301			
FL301		L + R Low Pass Filter	308620		
L301	16-42 mh	Inductor: Variable	308609		
L302, 303	45-215 mh	Inductor: Variable	308610		
R301	10K	Resistor: Fixed, ±5%, ½W	80361	AB	EB
		OUTPUT AMPLIFIER AND CATHODE FOLLOWERS			
C401	.047μf	Capacitor: Fixed, ±20%, 600V	83175	GA	663A
C402, 403	.1μf	Capacitor: Fixed, ±10%, 400V	82357	GA	663F
C404	.0047μf	Capacitor: Fixed, ±10%, 600V	82354	GA	620M
C405	270 pf	Capacitor: Fixed, ±5%, 500V	82237	EMC	CM20E271J
C406	1μf	Capacitor: Fixed, ±20%, 200V	83142	GA	620M
C407	.1μf	Same as C105			
C409	.01μf	Capacitor: Fixed, +80% —20% 450V	82428	CRL	DA048-003A
C410	80μf	Capacitor: Fixed, +50% —10%, 250V, dual 40 μf	83152	C-D	OUBX80241
C411A, B	40-40μf	Capacitor: Fixed, +50% —10%, 450V	83120	PRM	FP238
J401		Jack, Closed Circuit	89039	SI	#12
J402		Same as J201			
J403		Same as J202			
R401	10KΩ	Same as R301			
R402	100Ω	Resistor: Fixed, ±5%, ½W	80062	AB	EB
R403	1 Meg.Ω	Same as R106			
R404	510Ω	Same as R112			
R405	100Ω	Same as R402			
R406	1 Meg.Ω	Same as R106			
R407	510Ω	Same as R112			
R408	100Ω	Same as R402			
R409	1 Meg.Ω	Same as R106			
R410	8.2KΩ	Resistor: Fixed, ±5%, ½W	80326	AB	EB
R411, 412	10KΩ	Resistor: Fixed, ±5%, 1W	80331	AB	GB
R413	10KΩ	Same as R207			
R414	100Ω	Same as R402			
R415	1 Meg.Ω	Same as R106			
R416	1.8KΩ	Resistor: Fixed, ±5%, ½W	80234	AB	EB
R417	150Ω	Resistor: Fixed, ±5%, ½W	80098	AB	EB
R418	18KΩ	Resistor: Fixed, ±5%, 2W	80843	AB	HB
R419	47KΩ	Resistor: Fixed, ±5%, 1W	80470	AB	GB
R420	100Ω	Same as R402			
R421	1 Meg.Ω	Same as R106			
R422	1KΩ	Resistor: Fixed, ±5%, 2W	80151	AB	HB
R423	390Ω	Resistor: Fixed, ±5%, 1W	80836	AB	GB
R424	4KΩ	Resistor: Fixed, ±10%, 10W, WW	80837	SPR	10NIT/457E
R425	5KΩ	Resistor: Variable, ±10%, 2W	81226	CMC	53M
R426	180KΩ	Resistor: Fixed, ±5%, ½W	80558	AB	EB
R427	56KΩ	Resistor: Fixed, ±5%, ½W	80556	AB	EB
R428	150Ω	Resistor: Fixed, ±5%, 2W	80864	AB	HB

CIRCUIT SYMBOL	VALUE	DESCRIPTION	BRC PART NO.	MFG.	MFG'S TYPE NO.
R429	100Ω	Same as R402			
R431	100KΩ	Resistor: Fixed, ±5%, ½W	80517	AB	EB
S401		Switch, OUTPUT MODE	308544		
V401A, B		Same as V201			
V402A, B		Same as V202			
V403A, B		Electron Tube: 6DR7			
		METER CIRCUITRY			
C501-503	.1μf	Capacitor: Fixed, ±20%, 600V	83176	GA	663A
C504	2μf	Capacitor: Fixed, +250% —10%, 25V	82359	AER	PTT25002
C505	.0022μf	Capacitor: Fixed, ±10%, 600V	82335	GA	620M
CR501		Rectifier, Silicon: 400V, .5A 1N1763	91100		
CR502		Diode, Silicon: 1N662	98021		
M501		Panel Meter	92052-1		
R501	220KΩ	Same as R107			
R502, 503	8.2 Meg.Ω	Resistor: Fixed, ±5%, ½W	80645	AB	EB
R504	220Ω	Resistor: Fixed, ±5%, ½W	80188	AB	EB
R505	250Ω	Resistor: Variable, ±10%, 2W	81187	AB	Type J
R506	220Ω	Same as R504			
R507	1.8KΩ	Same as R416			
R508	68KΩ	Resistor: Fixed, ±5%, ½W	80549	AB	EB
R509	2.2KΩ	Resistor: Fixed, ±5%, ½W	80256	AB	EB
R510	100KΩ	Resistor: Variable, ±30%, 0.2W	81517	CTS	Type 70
R511	22KΩ	Resistor: Fixed, ±5%, ½W	80472	AB	EB
R512	1 Meg.Ω	Resistor: Variable, ±30%, 0.2W	81138	CTS	Type 70
R513	68KΩ	Same as R508			
R514	1 Meg.Ω	Same as R512			
R515	12KΩ	Same as R201			
V501A, B		Same as V201			
		L — R BAND PASS FILTER			
C601, 602	330 pf	Capacitor: Fixed, ±5%, 500V	82217	EMC	CM20503-JA330J
C604	510 pf	Capacitor: Fixed, ±5%, 500V	82233	EMC	CM20E511J
C605	100 pf	Capacitor: Fixed, ±5%, 500V	82123	AER	CM202C101J
C606	680 pf	Same as C302			
C608	1100 pf	Capacitor:: Fixed, ±5%, 500V	146201	SECO	KR-1211J
C609	1000 pf	Capacitor: Fixed, ±2%, 500V	82312	EMC	CM30D102G
FL601		L — R Band Pass Filter	308587		
L601	16-42 mh	Same as L301			
L602	45-215 mh	Same as L302			
L603-606	16-42 mh	Same as L301			
R601	22KΩ	Same as R511			
R602	100KΩ	Resistor: Variable, ±10%, 2W	81507	AB	Type JLU
R603	10KΩ	Same as R301			
R604	220KΩ	Same as R107			

CIRCUIT SYMBOL	VALUE	DESCRIPTION	BRC PART NO.	MFG.	MFG'S TYPE NO.
		BALANCED MODULATOR AND HARMONIC GENERATOR			
C701, 702	.01μf	Capacitor: Fixed, ±10%, 600V	82355	GA	663UW
C703	.047μf	Capacitor: Fixed, ±10%, 100V	82356	GA	663UW
C704, 705	300μf	Capacitor: Fixed, +250% —10%, 3V	83134	AER	PTT16DRPWE 3300
C706	.1μf	Capacitor: Fixed, ±20%, 100V	83124	GA	663A
C707, 708	300μf	Same as C704			
C709	8-60μf	Capacitor: Variable	84092	AEI	404
C710A,B,C	10-10-10μf	Capacitor: Fixed, 450V	83050	PRM	FP375.8
C711	.1μf	Same as C105			
C712	14-150 pf	Capacitor: Variable	84097	AEI	424
C713	.047μf	Same as C703			
C714	.47μf	Capacitor: Fixed, ±10%, 100V	83179	GA	663F
R701	47KΩ	Resistor: Fixed, ±5%, ½W	80923	CEC	C-20
R703	12KΩ	Resistor: Fixed, ±2%, 1W	80783	CEC	C-32
R704	10KΩ	Same as R207			
R705	47KΩ	Same as R701			
R706	15KΩ	Resistor: Fixed, ±5%, 2W	80338	AB	HB
R707	75KΩ	Resistor: Fixed, ±5%, ½W	80508	AB	EB
R708	5KΩ	Resistor: Variable, ±10%, 2W	81427	AB	Type J
R709	22KΩ	Resistor: Fixed, ±2%, 1W	80856	CEC	C-32
R710	47KΩ	Same as R701			
R711	1KΩ	Resistor: Fixed, ±2%, 1W	80846	CEC	C-32
R712	250Ω	Same as R113			
R713	5.6KΩ	Resistor: Fixed, ±5%, 1W	80922	CEC	C-32
R714	560KΩ	Resistor: Fixed, ±5%, ½W	80629	AB	EB
R715, 716	100KΩ	Same as R431			
R717	5.6KΩ	Same as R713			
R718	1KΩ	Same as R711			
R719	250Ω	Same as R113			
R720	150Ω	Resistor: Fixed, ±5%, 1W	80878	CEC	C-32
R721	560KΩ	Same as R714			
R722	1KΩ	Same as R711			
R723	150Ω	Same as R720			
R724	100KΩ	Same as R431			
R725	560KΩ	Same as R714			
R726	51Ω	Resistor: Fixed, ±5%, 1W	80877	CEC	C-32
R727	100KΩ	Same as R431			
R728	390Ω	Resistor: Fixed, ±5%, 1W	80879	CEC	C-32
R729	50Ω	Resistor: Variable, ±10%, 2W	81141	AB	Type J
R730	75KΩ	Same as R707			
R731, 732	82KΩ	Resistor: Fixed, ±2%, ½W	130204	CEC	C-20
R733	1KΩ	Same as R711			
R734	82KΩ	Same as R731			
R735	1KΩ	Resistor: Variable, ±10%, 2W	81140	AB	Type J
R736	82KΩ	Same as R731			
R737	1KΩ	Same as R711			
R738	22Ω	Resistor: Fixed, ±5%, ½W	80713	AB	EB

CIRCUIT SYMBOL	VALUE	DESCRIPTION	BRC PART NO.	MFG.	MFG'S TYPE NO.
T701		Transformer, Output	85090		
TP701-704		Same as TP101			
V701-704		Electron Tube: 7543			
V705A, B		Same as V202			
		19KC AND 38KC OSCILLATORS AND CATHODE FOLLOWERS			
C801	.01μf	Same as C409			
C802	1μf	Same as C406			
C803	.033μf	Capacitor: Fixed, ±10%, 600V	82444	GA	620M
C804, 805	.01μf	Same as C409			
C806	.0022μf	Same as C505			
C807	2μf	Same as C504			
C808	3000 pf	Capacitor: Fixed, ±5%, 500V (P/O L801)	82364	EMC	CM-30
C809, 810	.01μf	Same as C409			
C811	750 pf	Capacitor: Fixed, ±5%, 200VDC (P/O L802)	82362		
C812, 813	.01μf	Same as C409			
C814	2μf	Same as C504			
C815	.01μf	Same as C409			
C816A,B,C	10-10-10μf	Same as C710			
C817	.001μf	Capacitor: Fixed, ±1%	82340	C-D	5R501
C819, 820	.1μf	Capacitor: Fixed, ±5%, 200V	82446	GA	620M
C821	.01μf	Same as C409			
CR801-804		Diode, Crystal: 1N34A	91081		
J801		Jack, Open Circuit	89038	SI	#11
L801		Oscillator Tank Assembly: 19KC (includes C808)	308607		
L802		Oscillator Tank Assembly: 38KC (includes C811)	308608		
R801	10KΩ	Resistor: Variable, ±20%, ½W (includes switch S801)	81323	CTS	K-45
R802, 803	100Ω	Same as R402			
R804	470Ω	Resistor: Fixed, ±5%, ½W	80168	AB	EB
R805	470KΩ	Resistor: Fixed, ±5%, ½W	80640	AB	EB
R806	18KΩ	Same as R418			
R807	22KΩ	Same as R511			
R808	8.2KΩ	Same as R410			
R809, 810	470KΩ	Same as R805			
R811	470Ω	Same as R804			
R812	18KΩ	Same as R418			
R813	6.8KΩ	Resistor: Fixed, ±5%, ½W	80387	AB	EB
R814	100KΩ	Same as R431			
R815	8.2KΩ	Same as R410			
R816	39KΩ	Resistor: Fixed, ±5%, ½W	80452	AB	EB
R817	470KΩ	Same as R805			
R818	3.3KΩ	Resistor: Fixed, ±5%, ½W	80253	AB	EB
R819	100Ω	Same as R402			

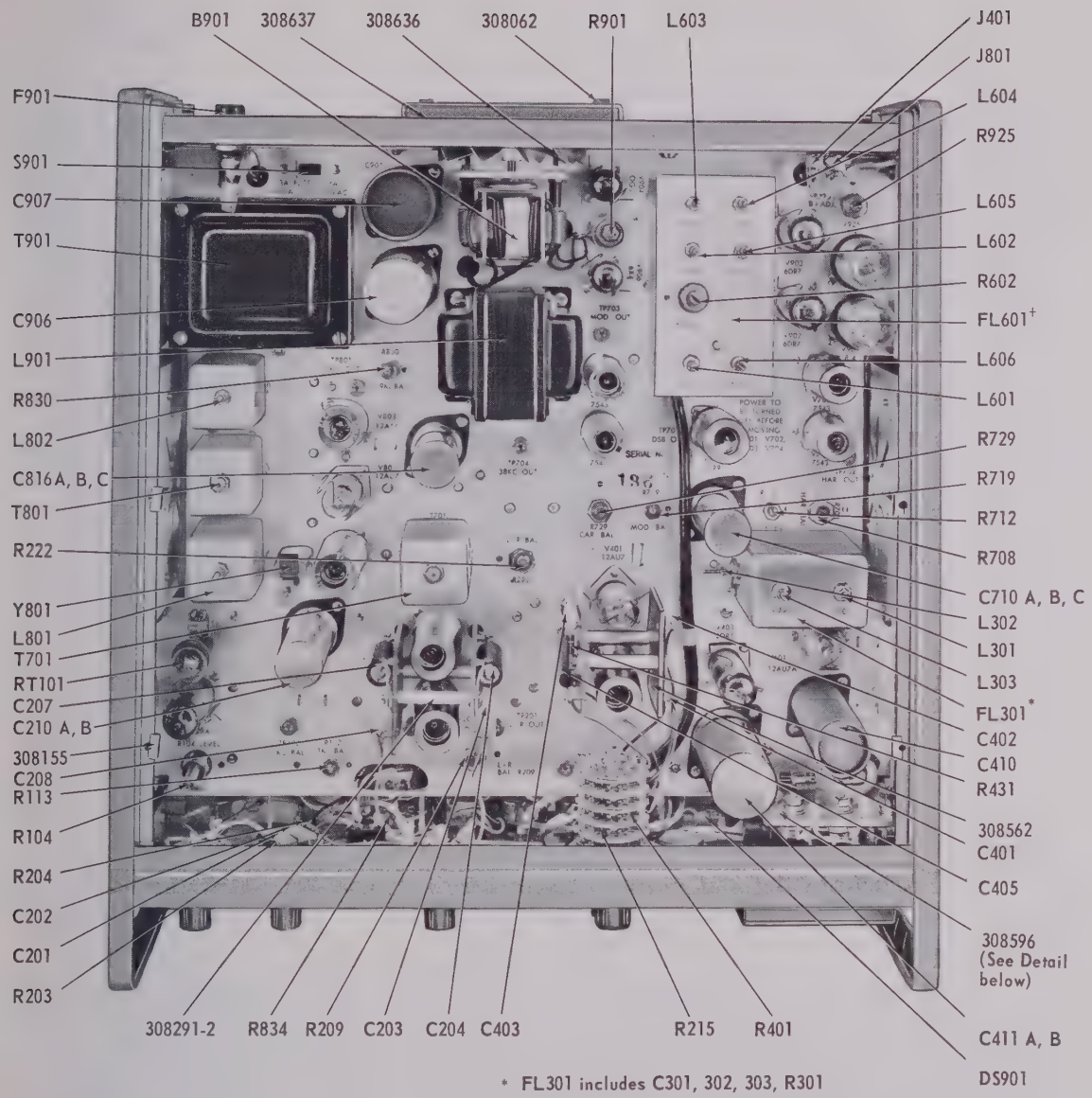
CIRCUIT SYMBOL	VALUE	DESCRIPTION	BRC PART NO.	MFG.	MFG'S TYPE NO.
R820	470KΩ	Same as R805			
R821	470Ω	Same as R804			
R822	18KΩ	Same as R418			
R823	22KΩ	Same as R511			
R824	100KΩ	Same as R431			
R825	470Ω	Same as R804			
R826	100Ω	Same as R402			
R827	18KΩ	Same as R418			
R828	470KΩ	Same as R805			
R829	1KΩ	Same as R422			
R830	5KΩ	Resistor: Variable, ±30%, 0.3W	81343	CTS	Type 70
R831	1.5KΩ	Resistor: Fixed, ±5%, ½W	80273	AB	EB
R832	22KΩ	Same as R511			
R833	27KΩ	Resistor: Fixed, ±5%, ½W	80298	AB	EB
R834	3.3KΩ	Same as R818			
R835	120KΩ	Resistor: Fixed, ±5%, ½W	80550	AB	EB
R836	820KΩ	Resistor: Fixed, ±5%, ½W	80620	AB	EB
S801		Switch, Push-Pull: Part of R801			
T801		Transformer, Output	85089		
TP801		Same as TP101			
V801A, B		Same as V201			
V802A, B		Electron Tube: 12AT7			
V803A, B		Same as V802			
Y801		Crystal: 19 KC	91111		
		POWER SUPPLY			
B901		Motor, Blower	308045	GI	G-5-CW
C901, 902	.1μf	Capacitor: Fixed, ±20%, 600V	83013	AER	P8292ZN28
C903	.0047μf	Same as C404			
C904	.1μf	Same as C105			
C905	1μf	Same as C406			
C906A, B	40-40μf	Same as C411			
C907	40μf	Capacitor: Fixed, 475V	148151	SPR	TVL1820
C908	25μf	Capacitor: Fixed, 25V	83129	AC	ET-25-25
C909	40μf	Capacitor: Fixed, 150V	148153	AER	PRS
CR901-904		Rectifier, Silicon: 1N1764	98006		
CR905		Rectifier, Diode: 82V ±10%, 1.5W	98015	MOT	1.5M82Z10
DS901		Lamp, Incandescent: 6.3V, .15A, 2-pin base	90910	GE	#12
F901		Fuse: 3A, 115V, 3AG2	95032	LTF	313.003
		Fuse: 1.5A, 230V, 3AG	93250	LTF	31201.5
L901		Choke, Filter: 160 ma, 180 ohms, 2500V	85453	FTC	RGC-20
P901		Receptacle, Male: 3-prong	308087	TMC	H1061-IG
R901	1250Ω	Resistor: Fixed, ±5%, 20W	135002	W-L	Type 20F
R902	3.9Ω	Resistor: Fixed, ±10%, 2W	134751	IRC	BWH
R903-906	470KΩ	Same as R805			
R907	25KΩ	Resistor: Fixed, ±5%, 5W, WW	80410	SPR	5KT
R908	470Ω	Same as R804			
R909	120KΩ	Same as R835			

CIRCUIT SYMBOL	VALUE	DESCRIPTION	BRC PART NO.	MFG.	MFG'S TYPE NO.
R910, 911	33Ω	Resistor: Fixed, ±5%, 1W	80771	AB	GB .
R912	470Ω	Same as R804			
R913	470KΩ	Same as R805			
R914	4.7 Meg.Ω	Resistor: Fixed, ±5%, ½W	80641	AB	EB
R915	120KΩ	Same as R835			
R916, 917	15KΩ	Same as R706			
R918	680KΩ	Resistor: Fixed, ±5%, ½W	80663	AB	EB
R919	39KΩ	Resistor: Fixed, ±5%, 1W	80429	AB	GB
R920	33KΩ	Resistor: Fixed, ±5%, ½W	80461	AB	EB
R921	470KΩ	Same as R805			
R922	33KΩ	Resistor: Fixed, ±5%, 2W	80754	CEC	C-42
R923	12KΩ	Resistor: Fixed, ±5%, 1W	80441	AB	GB
R924	5.6KΩ	Resistor: Fixed, ±5%, 1W	80854	AB	GB
R925	10KΩ	Resistor: Variable, ±10%, 2W	81342	CMC	53M
R926	18KΩ	Resistor: Fixed, ±5%, 2W	80853	CEC	C-42
R927	39KΩ	Resistor: Fixed, ±5%, 2W	80424	AB	HB
R928	68Ω	Resistor: Fixed, ±5%, 2W	80862	AB	HB
R929	18KΩ	Same as R926			
R930	33KΩ	Same as R922			
R931	2.7KΩ	Resistor: Fixed, ±5%, 2W	80745	CEC	C-42
S901		Switch, Snap Slide	88003	H-P	3101.0033
S902		Switch, Toggle: DPDT	88059	AH	81027CE
T901		Transformer, Power	308330		
V901		Tube, Ballast: 8-4			
V902A, B		Same as V403			
V903A, B		Same as V403			
V904		Electron Tube: OG3 (8228 used in some instruments)			
V905		Same as V901			
V906		Electron Tube: 6X4			
W901		Power Cord	308086		

TABLE OF REPLACEABLE MECHANICAL PARTS

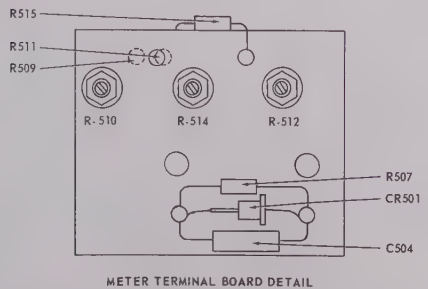
BRC PART NO.	DESCRIPTION	QTY. PER UNIT
88828	Shield, Tube (V703,704)	2
88861	Clamp, Loop: Burndy #HP-4N	1
89103	Socket, Crystal (Y801)	1
89111	Socket, Tube: 8-Pin Octal (V901,905)	2
89113	Socket, Lamp, (RT101)	1
89139	Socket, Tube: 7-Pin (V701,702,703,704)	4
89140	Socket, Tube: 9-Pin (V201,202,402,705,802,803)	6
89142	Lampholder Assembly (DS901)	1
90064-2	Terminal Board Assembly	2
90064-4	Terminal Board Assembly	3

BRC PART NO.	DESCRIPTION	QTY. PER UNIT
90064-5	Terminal Board Assembly	5
90064-8	Terminal Board Assembly	1
90067-1	Terminal Board Assembly	2
90071	Terminal Board Assembly	1
91300-2	Shield, Tube: 7-Pin, 1¾″ (V701,702)	2
91300-4	Shield, Tube: 9-Pin, 2″ (V201,202,402,705,802,803)	6
91318	Clip, Crystal (Y801)	1
91319	Ty-Rap Tie	4
91320	Ty-Rap Tie	5
93602	Mount, Capacitor: Bakelite	4
300331	Standoff, Insulated	19
304467	Clamp, Loop: Burndy #HP-5N	1
305659	Retainer, Tube (Base)	2
305660	Retainer, Tube (Base)	7
305661	Retainer, Tube (Wire)	4
305662	Retainer, Tube (Wire)	5
305664	Socket, Tube: 7-Pin (V904,906)	2
305665	Socket, Tube: 9-Pin (V101,401,403,501,801,902,903)	7
306100	Clamp, Loop: Burndy #HP-8N	1
306501	Mounting, Capacitor: Phenolic	3
306511	Fuse Holder (F901)	1
306575-1	Knob	1
306577-1	Knob	2
306581-1	Knob	1
306616	Knob	4
308062	Screw, Filter Retainer	2
308124	Foot Assembly	5
308132	Side Handle Assembly	2
308136	Strip, Large Filler	1
308137-21	Strip, Trim: Adhesive Backed	2
308140	Tilt Stand	1
308155	Clip, Tinnerman	8
308291-2	Spacer, Sleeve	4
308562	Terminal Board	4
308563	Terminal Board: Rectifier	1
308586	Insulator, Rectifier Terminal Board	1
308596	Terminal Board: Meter	1
308611	Bushing	3
308636	Blade, Fan	1
308637	Filter element	1



* FL301 includes C301, 302, 303, R301

\+ FL601 includes C601, 602, 604, 605, 606, 608, 609 and R601, 603, 604



METER TERMINAL BOARD DETAIL

Figure 22. Top View — 219A

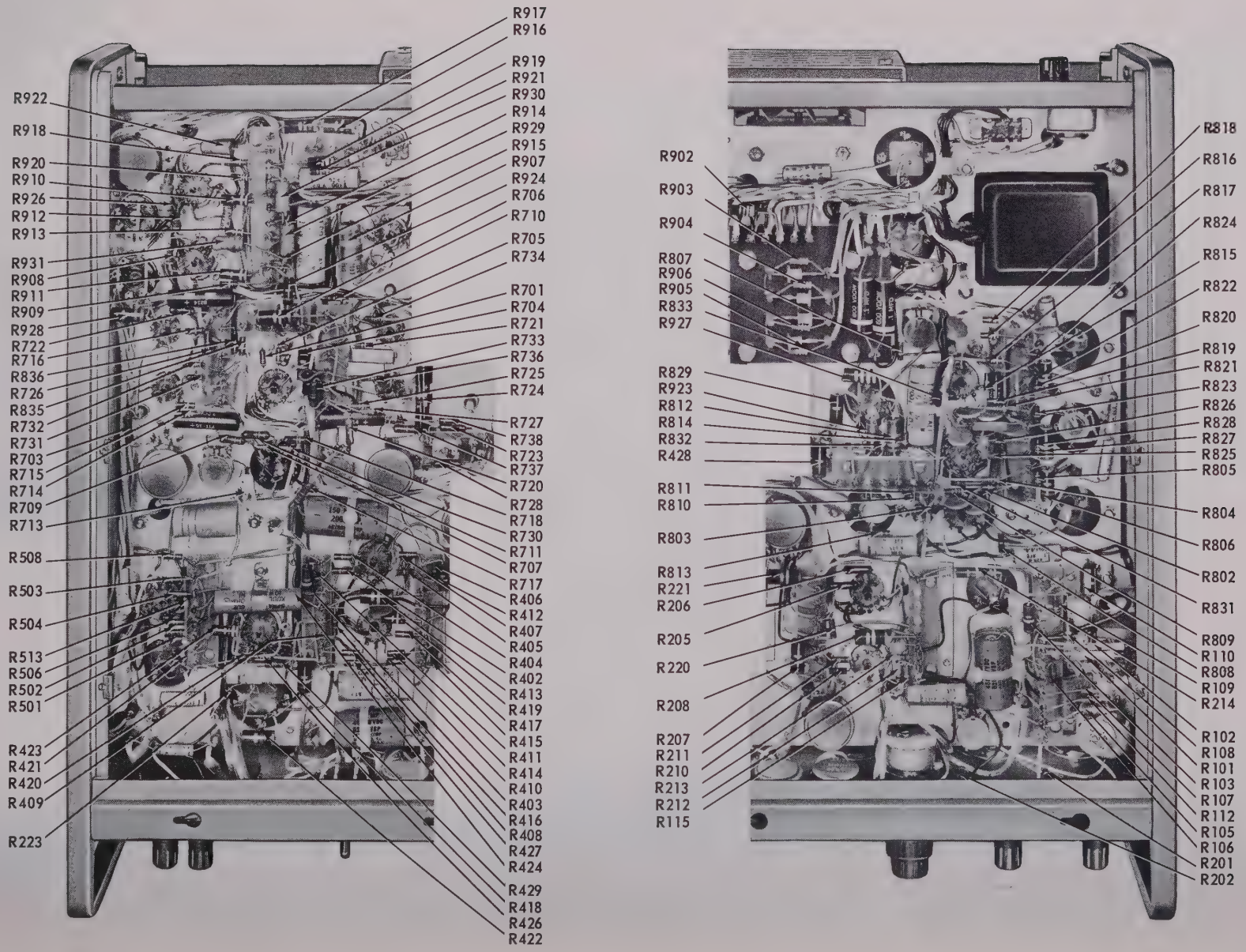


Figure 23. Bottom View — 219A (Resistors only)

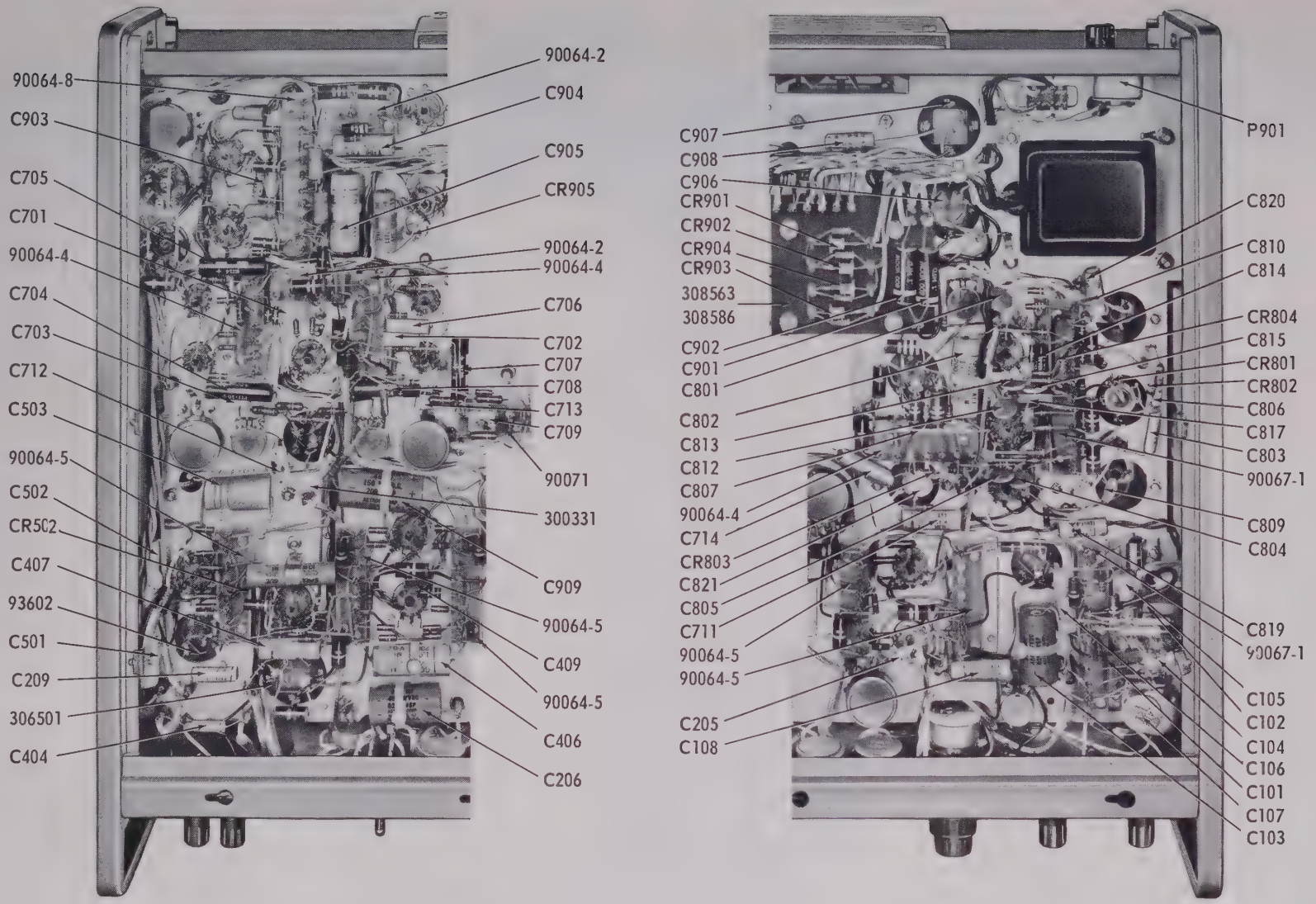


Figure 24. Bottom — 219A (Showing all Electrical Components except Resistors)

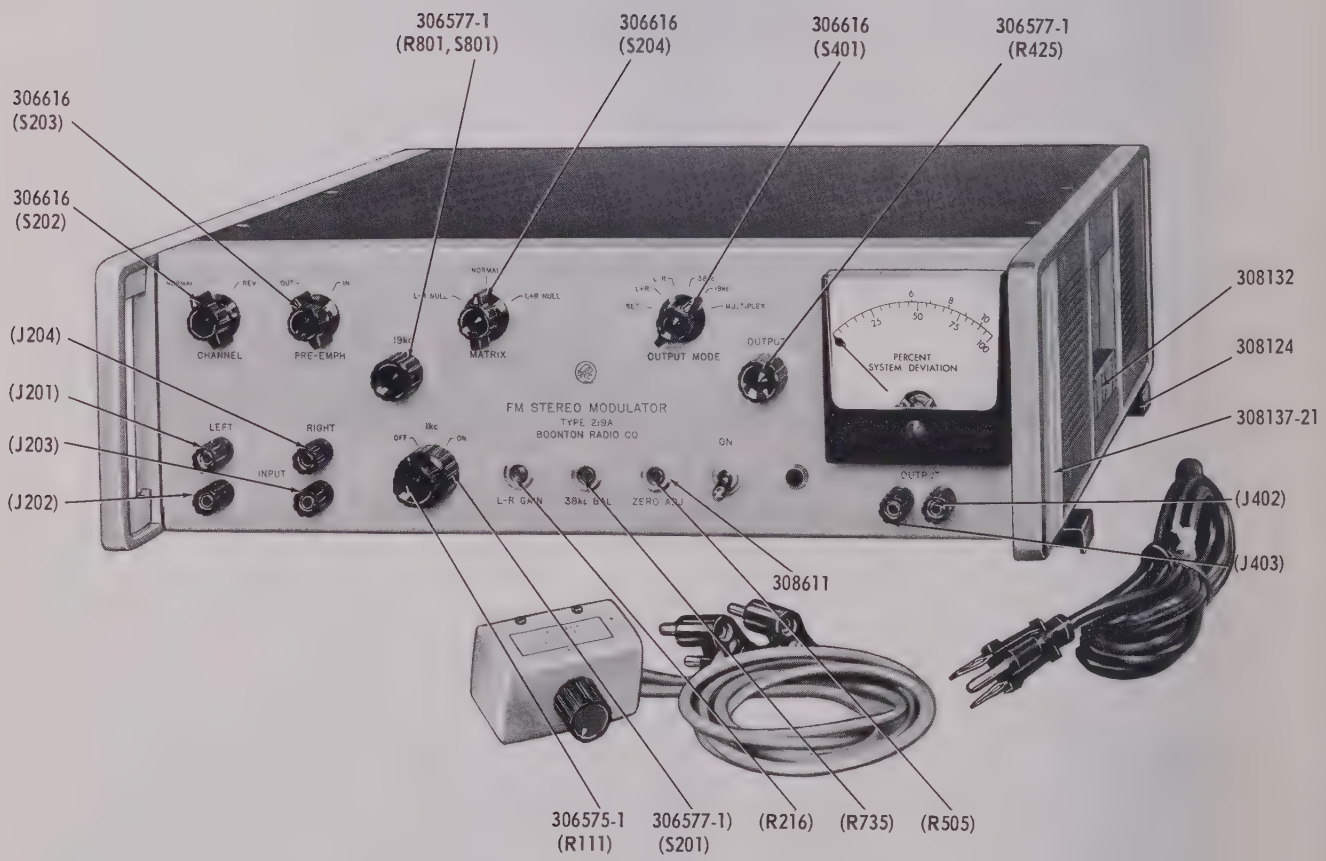
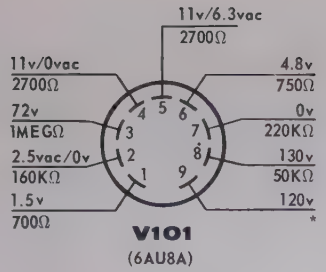
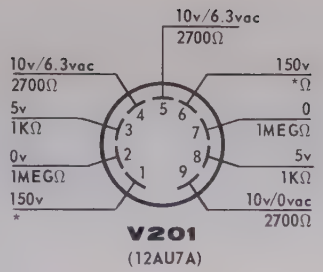
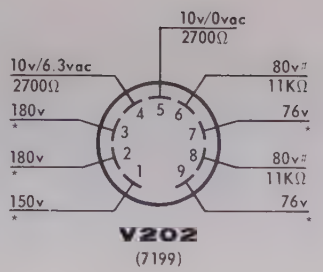
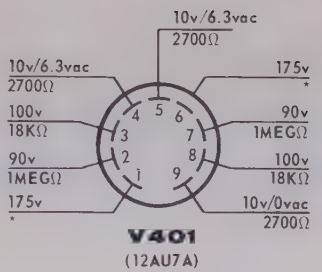


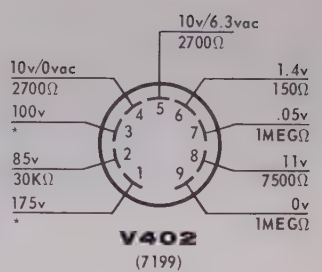
Figure 25. Front Panel Mechanical Parts

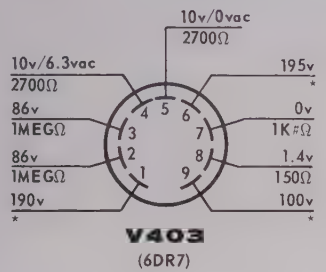


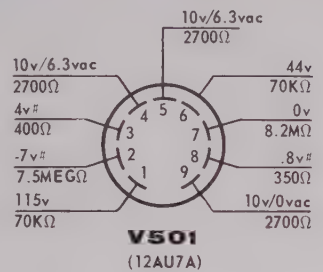


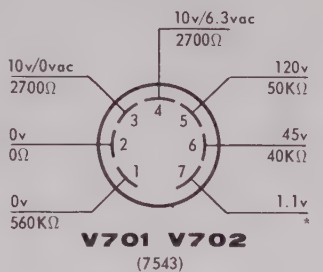


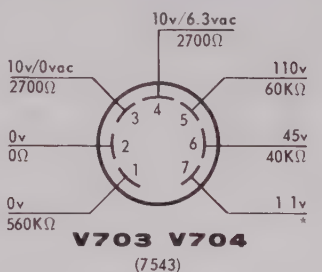


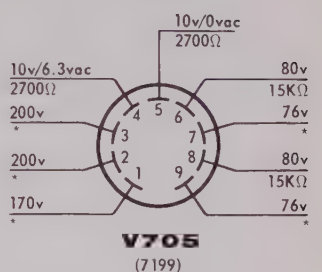


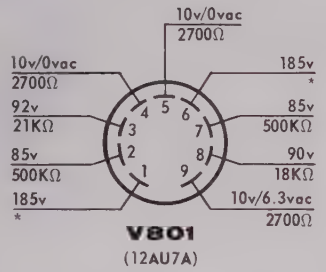


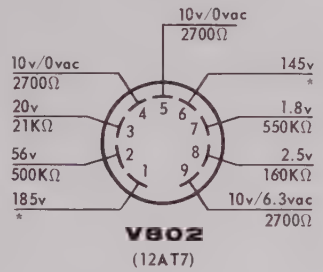


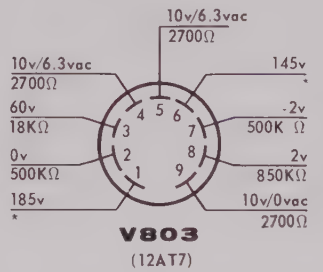


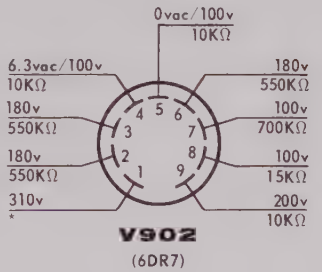


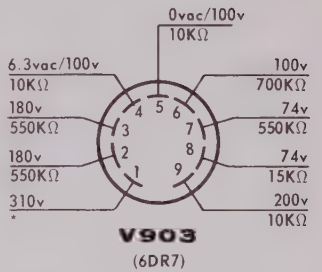


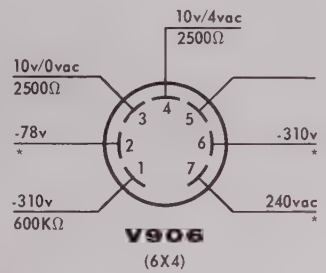


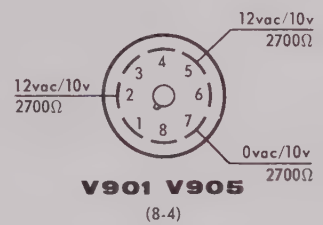


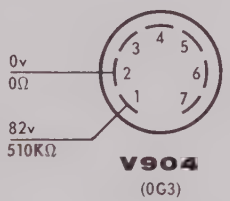










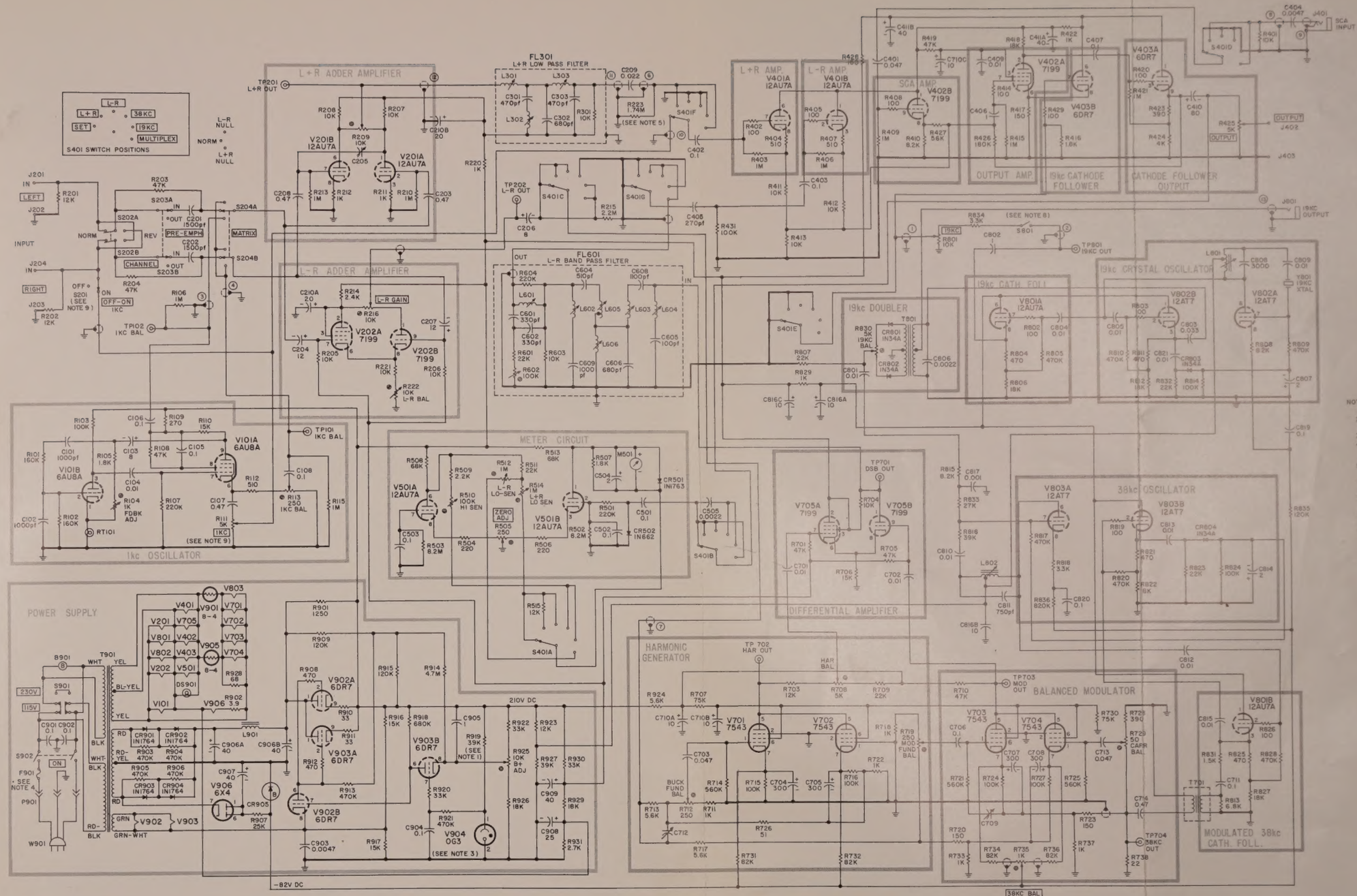


CONTROL SETTINGS

CHANNEL - NORMAL
PRE EMPH - OUT
MATRIX - NORMAL
OUTPUT MODE - MX
19KC SWITCH - ON
19KC CONTROL - ADJUST FOR 10% ON METER
1KC SWITCH - ON
1KC CONTROL - ADJUST FOR 45% IN L+R AND L−R POSITIONS

* NOT significant
# Varies with Control

VOLTAGE AND RESISTANCE CHART - TUBES



NOTES:

1. R919 IS 43K IN SOME UNITS.
2. ① - ⑭ INDICATES SHIELDED CABLE. NUMBERS, ⑤ NOT USED.
3. V904 IS 8228 TUBE IN SOME UNITS.
4. 3-AMP FUSE USED FOR 115V AC OPERATION, 1.5 AMP FUSE USED FOR 230V AC OPERATION.
5. R223 CONSISTS OF 2.2M AND 5.6M RESISTORS IN SOME UNITS.
6. RESISTANCE IS IN OHMS, UNLESS OTHERWISE INDICATED.
7. CAPACITANCE IS IN MICROFARADS, UNLESS OTHERWISE INDICATED.
8. S801 (PUSH-PUL SWITCH) IS LOCATED ON 19KC CONTROL (R801).
9. S201 (ON-OFF SWITCH) IS LOCATED ON R111 (1KC) CONTROL.

Figure 26. 219A Schematic

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